THE AMERICAN JOURNAL OF ROENTGENOLOGY
RADIUM THERAPY AND NUCLEAR MEDICINE

VOL. 80 OCTOBER, 1958 No. 4

UROLOGIC ROENTGENOLOGY: SOME CLINICAL APPLICATIONS*

HICKEY LECTURE, 1958

By REED M. NESBIT, M.D.
ANN ARBOR, MICHIGAN

THE Hickey Memorial Lecture honors the memory of a man who was respected and loved by all who knew him. He served his community well as a practitioner of otolaryngology, then embraced a new frontier with enthusiasm when roentgenology came into being. He was a pioneer in this field and used a common sense approach to its development as a diagnostic agency. One biographer said of him, "He took up the roentgen ray when it was a scientific curiosity and laid it down as one of the foundations of modern medicine."

Your present essayist was privileged to be associated with this great man in the twilight of Dr. Hickey's career as a teacher and diagnostician at the University of Michigan Hospital. Young men found him approachable and patient in the discussion of professional as well as personal problems; for Dr. Hickey always appeared to have an abundance of time to spend with them. Yet one knew that he carried a heavy load of administrative duties along with teaching and roentgen diagnosis.

He is remembered for his gentleness, his calmness, and his kindness. One of my first recollections of this good man was the observance that he was putting a blanket over a patient in a drafty hall when other people in the area, less busy, had not noticed the patient's distress. Dr. Hickey was not a dogmatic teacher; he asked the young man to reason out the answers. If he corrected a fault, it was always with a kindly, almost apologetic manner, accompanied by a sympathetic smile. He did not offend. Men were better doctors for having known and associated with Preston Hickey; they were inspired to emulate his reflective gentleness.

A woman was referred to the Department of Surgery in 1929 because she had chills and fever, some discomfort in the left side, and infected urine. Dr. Hugh Cabot was out of town, so the problem fell into unseasoned hands. Cystoscopy was performed and a ureteral catheter, introduced on the left side, could be passed only a short distance. Roentgenograms were made

* Presented before the Wayne County Medical Society, the College of Medicine of the Wayne State University, and the Detroit Roentgen Ray and Radium Society on March 6, 1958.

which failed to establish a diagnosis. The neophyte surgeon approached Dr. Hickey seeking help in solving the diagnostic problem for calculous disease was suspected yet had not been demonstrated. Dr. Hickey stroked his chin and seemed lost in reverie for a time, then suggested another attempt. He put the patient into the oblique position by slipping a pillow beneath her right flank in the hope that a stone shadow obscured by the bony shadows of the sacroiliac area in the anteroposterior projection might thereby be projected into the area of the thin ilium and be made visible. This maneuver indeed revealed the suspected calculus and a new diagnostic approach to the ureter was born.

The technique has been particularly useful in certain cases of ureteral neoplasm, as well as calculi, where the anteroposterior projection roentgenograms have failed to provide diagnostic shadows in the region in question. The oblique projection roentgenogram has also been useful in demonstrating that certain shadows, which appear to be in the ureter when observed in the anteroposterior projection, in fact lie outside the ureter. Indeed, many humiliating errors in diagnosis have been averted by observing parallax when a diagnosis of ureteral calculus has seemed certain.

No discussion of urologic roentgenology would be complete without some reference to excretory urography, which became a practical reality in 1929 when von Lichtenberg and Swick reported the successful use of uroselectan. The development of this compound comprises an interesting example of serendipity, for it was created by Professor Arthur Binz, who succeeded to Dr. Paul Ehrlich's chair and inherited all his notebooks of experimental data. Binz carried on further studies with the benzol ring in the hope of improving upon salvarsan, but failed; so tried the pyridine ring. He and his co-worker Räth combined iodine with the pyridine ring and this compound, which they called "selectan-neutral" was tried experimentally for the intravenous treatment of infections. It was not effective as an antibacterial agent but they found that the compound was partially excreted in the urine and might be utilized in outlining the urinary tract. This fortuitous discovery led the way to the deliberate creation of other compounds with greater iodine content which had lower toxicity. Thus Ehrlich's successor, instead of originating a new antisyphilitic drug, accidently became the father of excretory pyelography.

Today we have new and improved compounds that provide us with pyelograms that usually are equal in quality to retrograde studies, and they have the advantage of revealing information regarding the dynamic function of the urinary tract that cannot be obtained when catheters are employed.

Excretory pyelography continues to carry disagreeable complications in the nature of arm pain and nausea and vomiting, as well as allergic types of reaction. Fortunately, these reactions occur in only a small percentage of the cases and usually are of a mild nature, but occasionally a severe reaction occurs. Some terminate fatally. The occurrence of allergic reactions can be prevented in practically all instances by administering antihistamine drugs intravenously just before the injection of the iodine compound. When the antihistamine is taken orally or is given intravenously *along with* the iodine compound, the protection against allergic reactions is much less effective than when given intravenously several minutes before.

My associates and I have utilized this technique in over 3,000 cases, giving 50 mg. of diphenhydramine hydrochloride (benedryl—Parke Davis) intravenously a few minutes before the injection of the urographic medium by way of the same needle. Only 2 patients have had allergic reactions, very mild in nature. In this series no patients were rejected for excretory pyelography because of allergic history. Indeed, 3 patients who previously had experienced the most severe type of allergic reaction with shock were subsequently

examined by intravenous administration of the same contrast medium but following antihistamine premedication, and none developed any reaction whatever. Two of these were examined on the urology service and one on the roentgenology service where a series of necessary arteriographic studies was carried out by Dr. Melvin Figley who reported the incident to the present speaker.

Recently, investigations have been begun with a different antihistamine agent, promethazine hydrochloride (phenergan—Wyeth) which is known to be a profound antiemetic and yet has virtually no soporific effect in the dosage that is employed (12.5 mg. intravenously). This compound has been used for too short a time to provide data of any significance; however, there appears to have been a lessened incidence of nausea when this has been used and no allergic reactions. All of these data will eventually be reported when a large series of cases can be analyzed.

It has not yet been determined whether the shock-like reactions that sometimes terminate in death are allergic in nature. Some authorities in the field of pharmacology believe that they are; others ascribe this type of reaction to other causes. The occurrence of this reaction is so rare that no observer has had an opportunity, or indeed the time, to study it; and it has not occurred in experimental animals. We do not know whether antihistamine premedication will prevent this type of reaction. Only a large scale employment of antihistamine premedication in an enormous number of cases will eventually answer this question.

Many physicians who administer contrast media utilize a variety of screening tests in the hope of avoiding reactions by a proper selection of their patients. Yet reactions occur even when the tests are negative—in fact some of the reported fatalities have occurred in test negative cases. Many men who employ these tests in the full knowledge of their unreliability do so to protect themselves legally against the charge of carelessness in the event of disaster. It would seem more logical for all cautious minded physicians to use the simple procedure of antihistamine premedication which certainly will prevent nearly all allergic reactions and perhaps may prevent the more feared fatal or near fatal reaction.

If the value of antihistamine premedication were recognized by a large body of roentgenologists and urologists and employed by them for one or two years, and if these individuals would report any reactions to their respective professional societies, we would soon know if fatal or near fatal reactions could be prevented. It would seem that a humanitarian effort of this magnitude of importance might properly be promoted by your parent organization, as well as by mine. At least the suggestion could be offered to them for their consideration.

The clinician has often wondered whether excretory pyelography can be used for the accurate and reliable determination of renal function. Diodrast clearance is one of our most accurate tests of renal tubular function, but can the roentgenogram serve usefully as a practical measure of kidney function? One of my associates, Dr. Marvin Woodruff, is presently conducting an investigation in this matter. He has compared the density of the pyelogram with renal function, as determined by the fifteen minute phenolsulfonphthalein and the twenty-four hour creatinine clearance tests. Among 217 consecutive patients thus far studied who have had approximately normal values for these tests of renal function, 95 per cent had excretory pyelograms which exhibited a density on the five minute pyelogram which equalled or exceeded the density of the twelfth rib shadow. The latter criterion of density eliminates problems of film interpretation when variations in exposure techniques cause roentgen shadows to be dimly visible. Dr. Woodruff has demonstrated in his studies (to be reported) that pyelograms of lesser density cannot be used for interpretation of renal

Fig. 1. Intermittent hydronephrosis. Pyelograms made (*A*) while patient was free from pain and (*B*) during an attack.

function; a few of the normals, *e.g.*, normals with over amounts of hydration, as well as all of the cases of impaired function, will fall into this group. But when the pyelograms have the required density, the renal function tests have invariably been within a range that approaches the normal. Although other more quantitative tests of renal function should be utilized in following the subtle changes which may occur in the course of a renal disease, it is to be stressed that no single test other than intravenous pyelography can simultaneously afford an anatomic delineation as well as an index of adequate renal function.

Hydronephrosis ordinarily provides no problems of diagnosis for the reason that dilatation of the renal pelvis and widening of the infundibula and calyces are easily recognized. But the clinician must remember that persisting dilatation is a manifest evidence of continuing obstruction and that short term obstruction will produce only transient ballooning of the collecting system, which is made up of resilient and elastic muscle. Intermittent hydronephrosis (Fig. 1) is a clinical entity characterized by episodes of severe renal colic—Dietl's crisis—often brought on by exercise while in the upright position or occurring while riding in the sitting posture. In some instances, the attack can be relieved if the sufferer lies down flat and elevates the hips or alters the position of the body in such a manner as to move the kidney into its normal position, thereby unkinking the obstructed ureter. Patients who suffer from these agonizing episodes of pain will sometimes be found to have pyelograms that show persisting hydronephrosis, but in many the pyelograms will show normality for the reason that they are made after the attack is over when the obstruction has been relieved. In such cases the physician may have difficulty establishing a diagnosis even though he suspects the true nature of the trouble for there are many conditions other than acute hydronephrosis that give

rise to severe episodes of pain in the flank ur upper abdomen. Cholelithiasis, diverticulitis of the colon, abdominal aneurysm, spinal cord lesions, and coronary artery disease are a few that can be mentioned. In these instances, the diagnosis of intermittent hydronephrosis can be established only if pyelograms are made during an attack, and this diagnosis can be excluded only on the basis of normal pyelograms made during the attack.

Arteriography has been widely employed in urologic roentgenology since 1929 when dos Santos asserted its practical usefulness in demonstrating the arterial supply of the kidneys. This Portuguese surgeon employed sodium iodide in carrying out the techniques which he described, and the toxicity of this compound prevented a widespread acceptance of the method until safer chemicals were later developed.

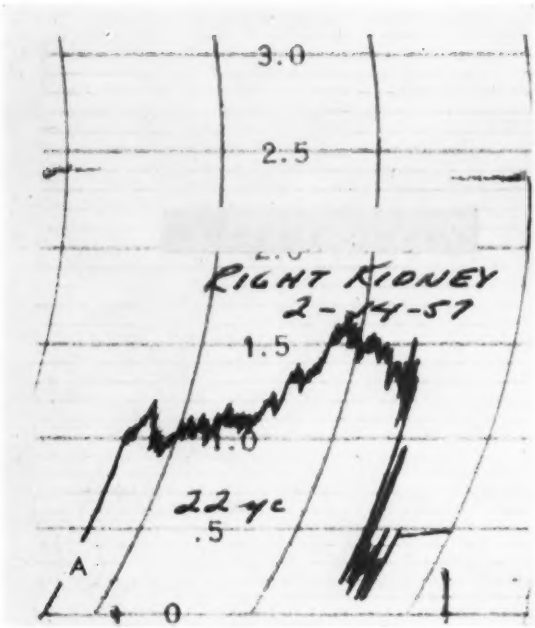
There is an amusing anecdote that relates to the early development of this procedure which deserves recording if only to amuse the historians that follow our own generation. One of our peripatetic and inquisitive urologists, Dr. Vincent O'Conor of Chicago, attended a Medical Congress in Europe shortly after arteriography had been first reported, so he visited the clinic of dos Santos in Lisbon and invited him to luncheon. O'Conor was anxious to determine just how safe aortography really was, so questioned his guest about the matter in terms that employed the usual parlance of an American but which were unfamiliar to the foreigner: "Do you use this procedure on private patients as well as on the service cases?" he asked. Dos Santos seemed not to understand just what was meant by the question, but finally was able to understand the real meaning of Dr. O'Conor's inquiry. Then he laughingly replied "I do aortography only on Spaniards, not on Portuguese!"

Today aortography is utilized by many urologists, not only in diagnosis but also in obtaining valuable information regarding the vascular supply of the kidney when operations for the salvage of hydronephrotic kidneys are contemplated. Many surgeons believe that the arteriogram provides information that determines whether a plastic procedure is apt to succeed or fail and also whether part of such a kidney should be removed or is apt to be useful.

There is no doubt that most tumors of the kidney can be identified as such by arteriography and also that cysts of the kidney can in nearly every instance be differentiated from neoplasms. But every experienced observer knows of exceptions that raise a doubt; furthermore, there are cysts of the kidney that contain neoplasm. We encountered 2 of these within the period of one month a short time ago. One must conclude that arteriography is rarely an essential or determining test in the differentiation of tumor deformities observed by pyelography, so this procedure has in reality only a limited usefulness in this connection.

Recently there has been an increasing use of renal arteriography in the study of hypertension, for some hypertensive patients are thereby demonstrated to have occlusive lesions of the renal artery that heretofore had rarely been seen or even suspected. The work done at The Cleveland Clinic in this connection has given rise to a great awakening to the possibility of curing severe hypertension in a significant number of individuals who previously were doomed to die of the disease. Today many clinicians, previously fearful of the inherent dangers of renal arteriography, are employing the procedure in the investigation of acute severe hypertension, and occlusive arterial disease is being discovered in many of the cases.

Two years ago Dr. C. Winter at the University of California at Los Angeles Medical Center developed a test which employs radioactive I^{131} tagged diodrast for determining the vascular status of the kidneys. He injects 1 cc. of tagged diodrast intravenously, then places scintillation counters over the two kidneys and obtains recordings of the uptake in both areas simultaneously. The test is devoid of reactions and



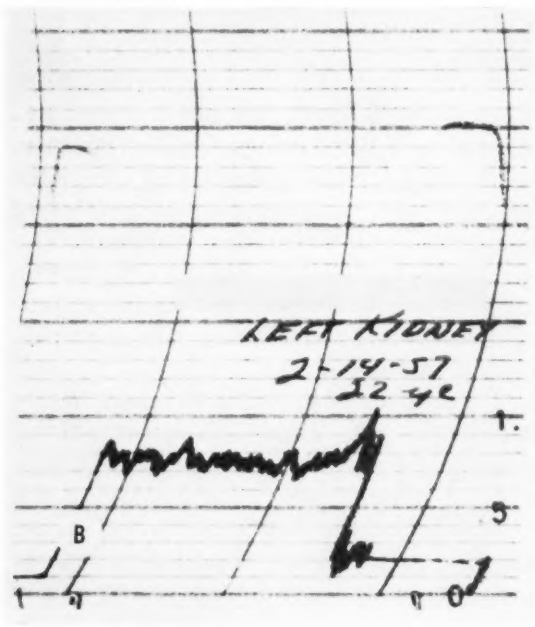


FIG. 2. Renogram using radioactive I^{131} tagged diodrast: (*A*) normal, (*B*) abnormal.

produces no discomfort. It takes about five minutes to perform. Dr. Winter believes that this test is highly accurate in demonstrating vascular impairment. We have utilized the test in a large variety of renal conditions for nearly two years and have found it to correlate perfectly in all hypertensives where the arteriogram has demonstrated narrowing of the renal arteries. Our present practice is to employ the radioactive diodrast renogram in all hypertension patients who are studied by excretory urography. The test is performed the day after pyelography and the pyelogram affords an accurate guide in placing the counters. When the renogram reveals a *vascular* abnormality on one kidney only (Fig. 2), then arteriography is indicated. This screening program obviates the need for arteriography in all but the occasional hypertensive patient.

The use of gas as a contrast medium in urology was first described in 1921 by Carelli and Sordella and by Rosenstein, but the method was not widely employed clinically until 1935, when Dr. George Cahill of New York reported the use of perirenal air insufflation to determine the presence of a suspected adrenal tumor. Following Cahill's report, the method was generally accepted and used but soon there appeared reports of death from air emboli and pneumography rapidly lost favor. Oxygen was used instead of air by some investigators who felt that the risk of emboli would be reduced, but oxygen too has been known to produce fatal emboli. Recently Ransom, Landes and McLelland collected data on 58 deaths from pneumography by personal communications with all of the urologists in the United States and published a report. The number of fatalities that were revealed in this study was a shocking revelation and a reminder that physicians are prone not to make reports concerning sporadic accidental deaths. These authors not only emphasized the significant dangers of air and oxygen retroperitoneal insufflation, but also suggested that carbon dioxide be used instead, since it is known that this gas can be injected intravenously without harm. Ransom, Landes and McLelland asserted no claim of priority in their recommendation of carbon dioxide for they pointed out that the original report of Carelli advocated the safety of this medium. Carbon dioxide has now become the accepted contrast

medium for perirenal pneumography but it has the disadvantage of very rapid absorption, so that large amounts of the gas must be used, and the roentgenograms must be made without delay if satisfactory contrasting gas shadows are to be obtained.

Pediatric urology is another area in which roentgenology has played a significant role in contributing to our knowledge of some of our most baffling and frustrating problems. I refer particularly to the child who wets himself regularly after he should be toilet trained, or one who has suffered from recurrent urinary tract infections which have failed to resolve under all forms of medical treatment and who mysteriously develops dilatation of the ureters and kidneys and eventually succumbs to renal failure. Urologists have wrestled with these problems in children and have not found the answer. One could list a long catalogue of theories that have been proposed to explain the disorder and also enumerate a variety of operations that have been designed for its correction, and most of these have not revealed the cause or corrected the disturbance.

However, recently developed roentgenologic techniques are providing information not previously known about the dynamics of the urinary tract in many of these cases; and bits of knowledge, gradually accumulated to be sure, but pieced together like a jig-saw puzzle, seem now to point the way to an understanding of the problem.

Dr. C. Montgomery Stewart of Los Angeles in 1953 observed that delayed cystograms and cystograms made during micturition will often reveal reflux not demonstrated by immediate cystograms in children who suffer from recurrent urinary tract infections. This technique has also demonstrated that significant dilatation of the ureter and renal pelvis observed on the delayed cystogram can occur in children whose excretory pyelograms are entirely normal (Fig. 3). Stewart was not the first person to observe the phenomenon of ureteral reflux, nor was he the first to suggest that reflux does not occur in a normal urinary tract, but his report served as a stimulus for a renewed interest in the subject which has set off a chain reaction of observations not previously made.

We now know that the majority of children who display this phenomenon have been found to have some sort of obstructive lesion at the outlet of the bladder. In the majority of these cases, the obstruction is found to be a contraction ring made up of hyperplastic muscle at the bladder outlet. One female child in the University of Michigan series was found at operation to have a ring of muscle 2 cm. thick encircling the bladder outlet, similar to the condition found in pyloric stenosis. Congenital valves occurring in the urethra of boys are another cause of obstruction at the bladder outlet.

These lesions are sometimes visible by endoscopic examination but in many cases the urologist is not able to see any lesion and must rely on corroborative evidence of obstruction: trabeculation of the bladder and residual urine. These comprise manifest evidences of obstruction—but the thoughtful clinician cannot help from wondering whether obstruction may be present in certain cases that are seen too early to reveal gross trabeculation or residual urine—yet suffer the complications of infection and ureteral reflux.

My own belief that this can occur is somewhat substantiated by clinical experience with cases exemplified by the following. An eleven year old girl had suffered from continuous urinary infection since the age of four. For seven years she had been on a variety of drugs constantly; for whenever antibacterial agents were stopped she became septic and had bladder irritation of a severe nature and the urine became heavily infected with *Escherichia coli*. This child was found to have no residual urine and her bladder showed no trabeculation when observed by cystoscopy. But the excretory pyelograms showed minimal hydronephrosis on the right side (Fig. 4*B*) and the delayed cystogram demonstrated right ureteral reflux (Fig. 4*A*). In an act of thera-

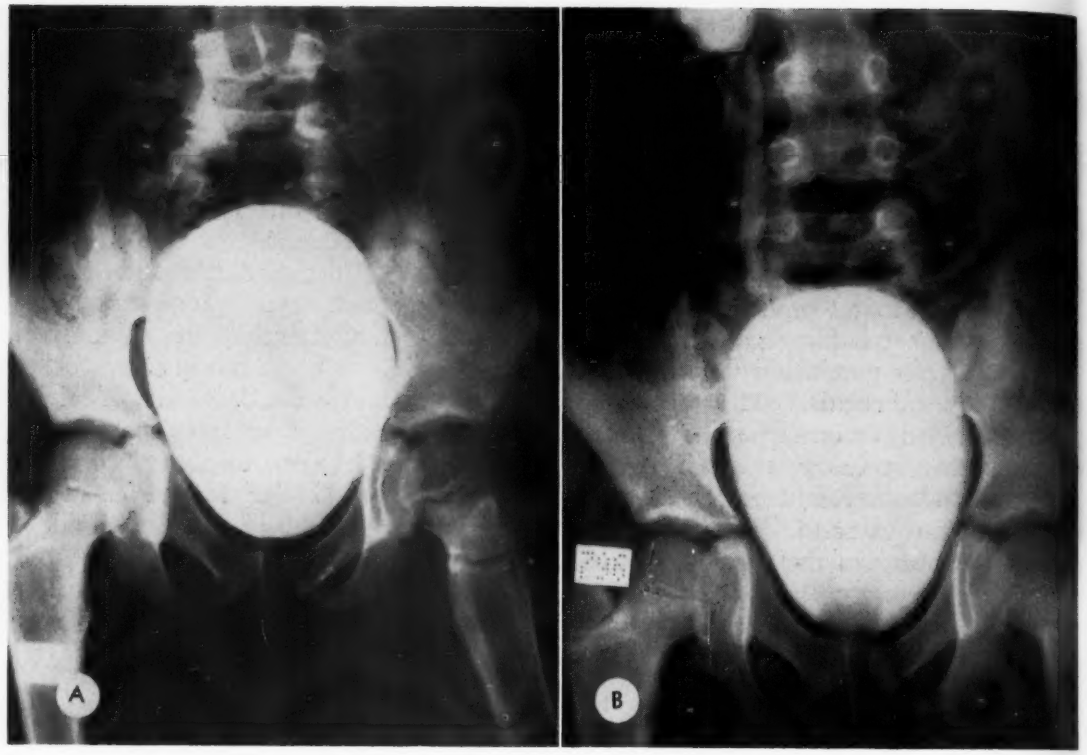


Fig. 3. (*A*) Immediate and (*B*) delayed cystogram, revealing ureteral reflux on delayed (30 min.) cystogram.

peutic desperation, this girl was operated upon by the retropubic approach, and a palpable contraction ring at the bladder outlet was found. The obstruction was corrected by a simple procedure described by Dr. Bradford Young of San Francisco. A vertical incision through the constricted bladder neck was closed transversely so as to enlarge the outlet. After operation this child volunteered the information that she urinated more easily than before—yet neither she nor her mother had previously recognized any impediment. Also, her infection cleared up entirely without medication and has not recurred in four years since the operation. Likewise, the dilatation, as well as the reflux of the right ureter, disappeared following operation (Fig. 4*C*).

Early diagnosis of these cases is urgently important and efforts are being made in many clinics, both here and abroad, to develop criteria that will permit the recognition to be made before permanent damage has occurred. Perhaps the most important work that is being done today is in Stockholm, Sweden, and the recent monograph on the subject by Kjellberg, Ericsson and Rhude describes the techniques that they employ in making voiding urethrocystograms which reveal an amazing demonstration of urethral valves and bladder neck obstructions that have never before been recorded on the roentgenogram. This work comprises the greatest step that yet has been made in our knowledge of the disorder in question.

These authors as well as some of our American investigators have brought forth evidence that ureteral reflux may occur in children who have infection yet do not have obstruction at the bladder outlet. The phenomenon of reflux in unobstructed cases has been ascribed to infection, to neurogenic abnormality as well as other less definite causes. No doubt the new roentgenologic techniques that are develop-

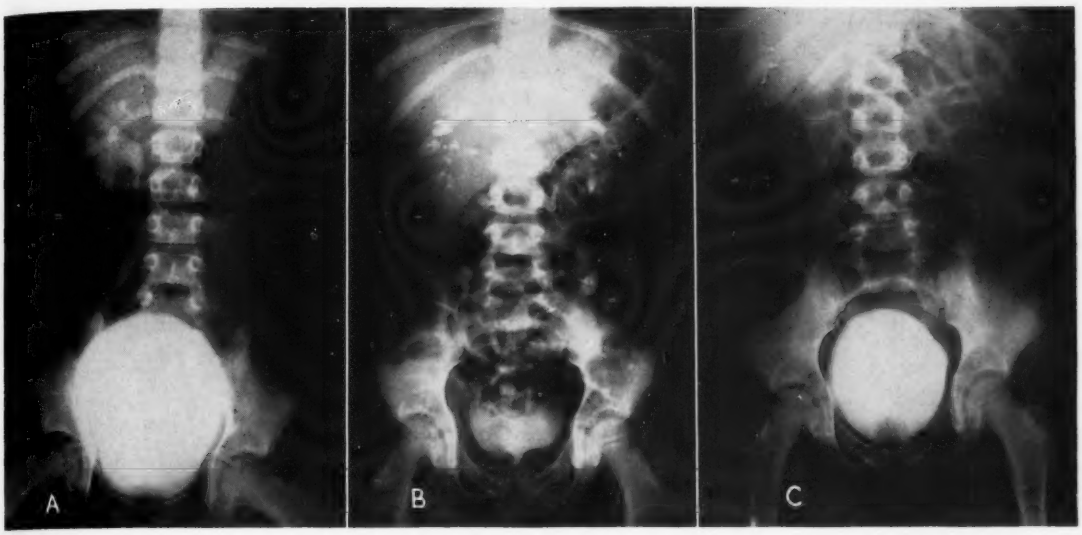


Fig. 4. (*A*) Reflux on delayed cystogram in a child with recurrent infection. (*B*) Excretory pyelogram shows minimal hydronephrosis on the right side. (*C*) Delayed cystogram following relief of bladder neck obstruction: reflux has spontaneously cleared.

ing may eventually enlarge our knowledge of ureterovesical dynamics in ways that will help to answer some of these unsolved problems. But we who employ these tools must reckon the cost in terms of gonadal roentgen injury and develop methods of protection for our pediatric patients.

The importance of early recognition in obstructive cases is emphasized by a knowledge that the majority are seen late when great damage to the urinary tract has occurred; many hopelessly irreversible. A few examples may be cited that will point up certain facets of the problem:

A five year old boy was brought to our clinic in 1944 suffering from constant dribbling urine and repeated episodes of chills and fever. He had been sick since infancy. He was noted to have a distended bladder and blood analysis revealed him to be uremic. A catheter was introduced and a cystogram demonstrated reflux up both ureters and massive dilatation of both ureters and kidneys (Fig. 5). He had an atonic

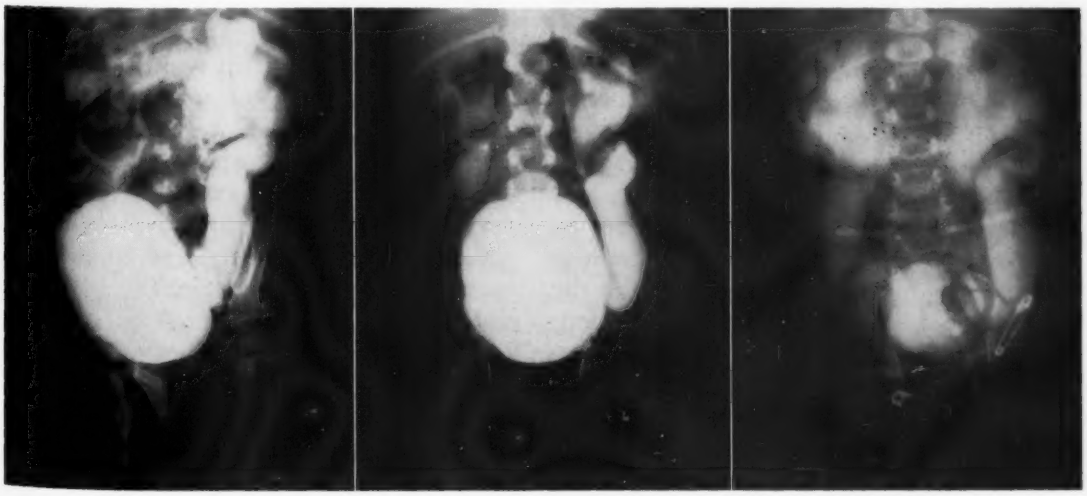


Fig. 5. Cystograms of a five year old uremic boy showing massive hydronephrosis due to valves in urethra.

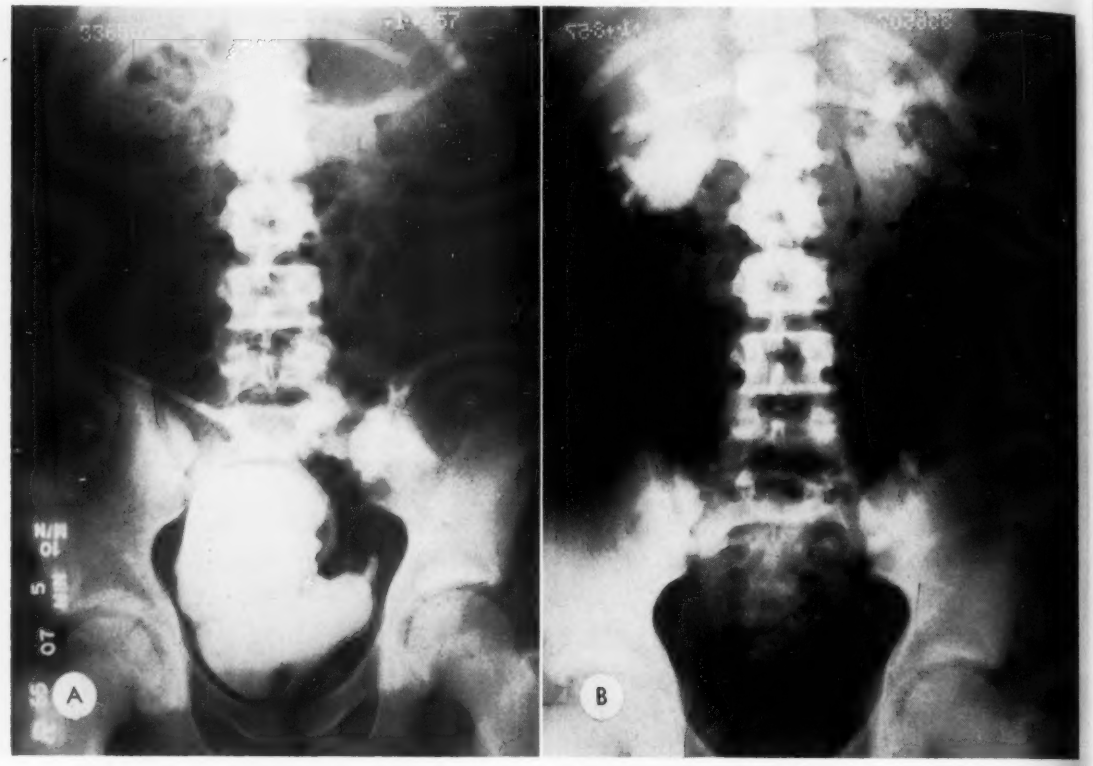


Fig. 6. (*A* and *B*) Pyelograms in same boy thirteen years later disclosed marked improvement and the cystogram revealed no reflux.

bladder. He was put on suprapubic drainage in the hope that he might survive for awhile. Three years later he had made significant clinical improvement and excretory pyelograms demonstrated a reduction in the hydronephrosis, but the ureters were still massively dilated. At this time a new resectoscope of extremely small size had been developed so an inspection of the bladder outlet was made and obstructing valves were found and excised. He did not void well because the bladder was still atonic so he was kept on constant suprapubic drainage two more years. In 1949 he was able to urinate and empty the bladder but still had massive ureteral reflux so the suprapubic tube was left in as a safety measure and the boy and his parents were instructed in changing it themselves. They lived 250 miles from Ann Arbor.

In 1957 the boy's father telephoned to ask whether the tube could be removed. He said they hadn't brought him in for eight years because he was getting along so well. It was a rewarding experience to see the eighteen year old high school senior: he was a leader in his school, played on most of the athletic teams, and was captain of one. He emptied his bladder completely; there was only minimal dilatation of the kidneys (Fig. 6) and his renal function was nearly normal. The suprapubic tube was removed and he has remained well and is free from infection. This is an example of one of the worst of the cases—one that has survived. There have been many who died.

Last month a woman brought her four year old son in for examination. She is a graduate nurse and lives in Ann Arbor and had heard the story of urinary obstruction in children and what to look for in its recognition. It is taught in the Well Baby Clinic. She said that her son urinated with an off center but forceful stream, and that the child appeared to strain to urinate

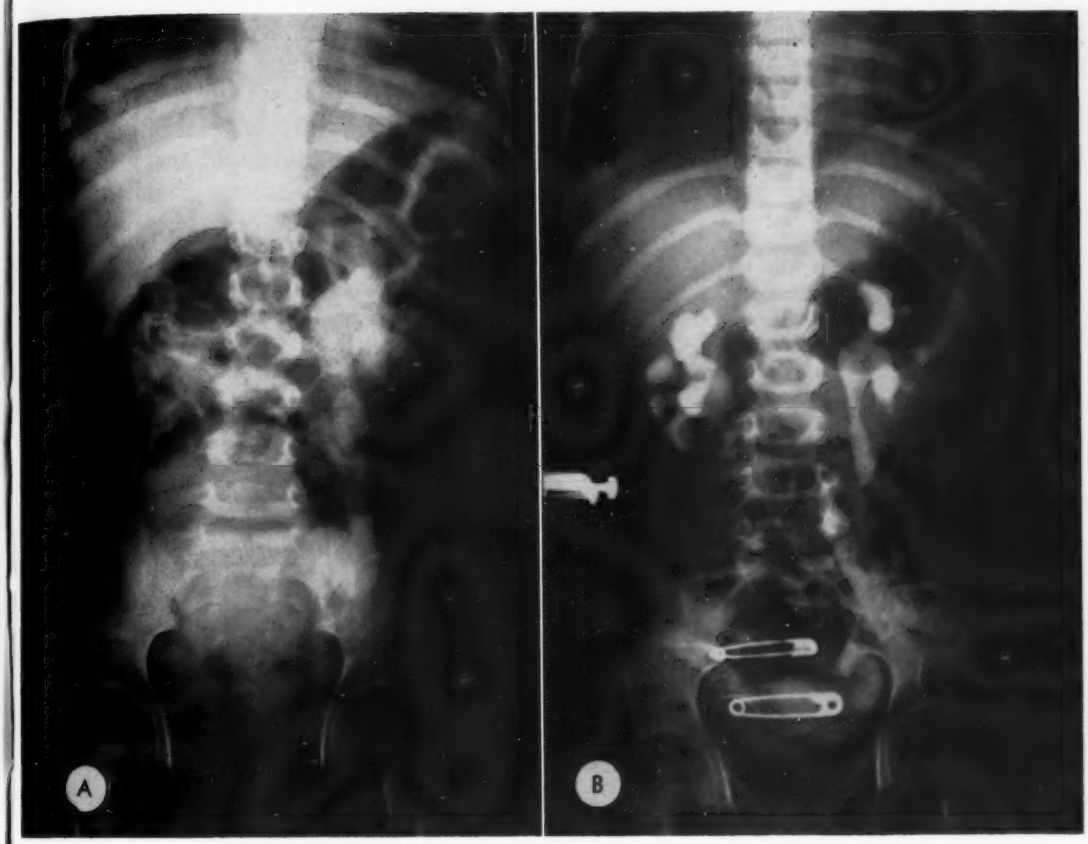


Fig. 7. (*A*) Bladder outlet obstruction in a four year old boy. No residual urine was demonstrated but there was marked hydroureter and hydronephrosis. (*B*) Second pyelogram two weeks following relief of bladder outlet obstruction revealed significant improvement.

first thing in the morning but not the rest of the day. There were no other symptoms. I saw him urinate and found indeed that his stream did not go in the proper direction; it was probably about 15 degrees to the right of center but it was a full and forceful stream. Excretory pyelograms were made which demonstrated great dilatation of both ureters and renal pelves (Fig. 7*A*). Cystoscopy revealed a residual urine of only 25 cc. and the bladder was grossly trabeculated. Cystograms demonstrated no reflux on either side. The absence of ureteral reflux in cases of severe bladder outlet obstruction is not uncommon, but why one case is spared this complication, while another develops it even very early, is one of the unexplained complexities of this condition.

This boy was operated upon by the Bradford Young technique, and two weeks later emptied his bladder completely with a straight and forceful stream, and does not strain to urinate at any time. Excretory pyelograms made at the time of discharge from the hospital disclosed a significant improvement in the upper urinary tract dilatation (Fig. 7*B*). This case is presented to demonstrate an example of severe disorder in a child who had a relative absence of symptoms, and it emphasizes the importance of complete urologic evaluation whenever any child displays evidence of abnormality in urinary function—no matter how insignificant.

Our Well Baby Clinics teach mothers to observe the sucking and bowel functions of their newborn children: Let them also teach the mothers to observe the micturitional behavior of their babies. For the nor-

Fig. 8. The normal male child urinates with a high trajectory, forceful and continuous stream (Brussels statue).

mal infant urinates with a copious high trajectory stream that is at once the source of curious pride to the mother and the secret envy of the father, and the child empties the bladder with an uninterrupted and continuous stream. The child who does not void in this manner—emulating the boy in a famous Brussels statue (Fig. 8)—should have a urinary tract investigation.

We must recognize and teach that small children like senescent men often are afflicted by urinary obstructive disorders, yet the child is inarticulate and lacks an understanding in these matters that his adult counterpart possesses. We must discover them early in life and prevent irreparable damage. Most of the studies in these children take time and often require long periods of observation. They are best carried out in the hospital, yet the clinician often encounters a resistance to this practice which is prompted by emotional or economic considerations. Hospitalization at the twilight of life has become an accepted method of dealing with geriatric problems, but dollars spent on hospitalization at life's sunrise will often yield results that are more satisfying and lasting.

This has been a discussion of a few significant developments in urologic roentgenology that have evolved during the professional lifetime of a man who knew and was inspired by Dr. Preston Hickey. I am grateful to you for inviting me to share this occasion with you—for his memory is worthy of our respect and devotion.

1313 E. Ann Street
Ann Arbor, Michigan

Vol. 80, No. 4

PYELOGRAPHIC DIAGNOSIS OF LESIONS OF THE RENAL PAPILLAE AND CALYCES IN CASES OF HEMATURIA*

By BENJAMIN S. ABESHOUSE, M.D.,† *and* JULIAN O. SALIK, M.D.‡
BALTIMORE, MARYLAND

ONE of the most difficult problems in urology and radiology is the diagnosis of the causes of hematuria of renal origin. Among these the lesions of the renal papillae and calyces constitute a most perplexing group. The recent improvements in diagnostic methods have practically eliminated all the diagnostic uncertainties of the group of obscure cases of renal hematuria—the so-called group of "essential" or "idiopathic" hematuria of the past.

The purpose of this paper is to present the pertinent roentgenographic features of the various lesions of the renal papillae and of the major and minor calyces. These lesions are tabulated in the following classification.

DISEASES OF THE RENAL PAPILLAE AND CALYCES

I. *Inflammatory hyperplastic lesions*
   1. Nonspecific granuloma
   2. Specific granuloma
   3. Proliferative solitary polypoid hyperplastic granuloma
   4. Pyelitis cystica; pyelitis granulosa
   5. Localized hyperplastic cystic formation

II. *Metaplastic lesions*
   1. Foam cell granuloma

III. *Nonspecific infections*
   1. Pyelonephritis, acute, chronic and focal
   2. Hemorrhagic papillitis
   3. Necrotizing papillitis
   4. Abscess of the kidney, solitary or multiple

IV. *Specific infections*
   1. Tuberculosis; tuberculoma
   2. Syphilis; gumma

V. *Cystic lesions*
   1. Serous cyst, superficial and deep
   2. Papillary cyst
   3. Pyelogenic cyst
   4. Calyceal diverticulum
   5. Hydrocalyx
   6. Multiple cysts of pyramids; "sponge" kidney
   7. Peripelvic cyst
   8. Echinococcus cyst
   9. Polycystic disease, unilateral and bilateral

VI. *Benign tumors*
   1. Adenoma
   2. Lipoma; replacement lipomatosis
   3. Fibroma
   4. Hamartoma

VII. *Malignant tumors*
   1. Tubular origin—adenocarcinoma, hypernephroma
   2. Epithelial origin—squamous cell carcinoma, papillary carcinoma of the pyelocalyceal system

VIII. *Vascular tumors*
   1. Benign—varix, angioma
   2. Malignant—hemangiosarcoma, etc.

IX. *Miscellaneous lesions*
   1. Nonradiable calculi
   2. Crystalloid infarction or infiltration of the papillae
   3. Renal infarction and embolism
   4. Leukoplakia
   5. Malacoplakia
   6. Papillary infiltration by hemopoietic disease
   7. Papillary involvement by metastatic tumors
   8. Endometriosis
   9. Actinomycosis
   10. Perirenal hematoma or abscess

I. INFLAMMATORY HYPERPLASTIC LESIONS

1. *Nonspecific Granuloma.* This is more often multiple than single and may involve any portion of the pelviocalyceal system as well as the cortex and medulla. It is most frequently observed in association with acute or chronic pyelonephritis, pyonephrosis, nephrolithiasis and abscesses of the renal parenchyma. The nonspecific granuloma is usually dark red in color and bleeds easily on simple manipulation or

* From the Departments of Urology and Radiology, Sinai Hospital of Baltimore, Inc., Baltimore, Maryland.
† Urologist-in-Chief.
‡ Radiologist-in-Chief.

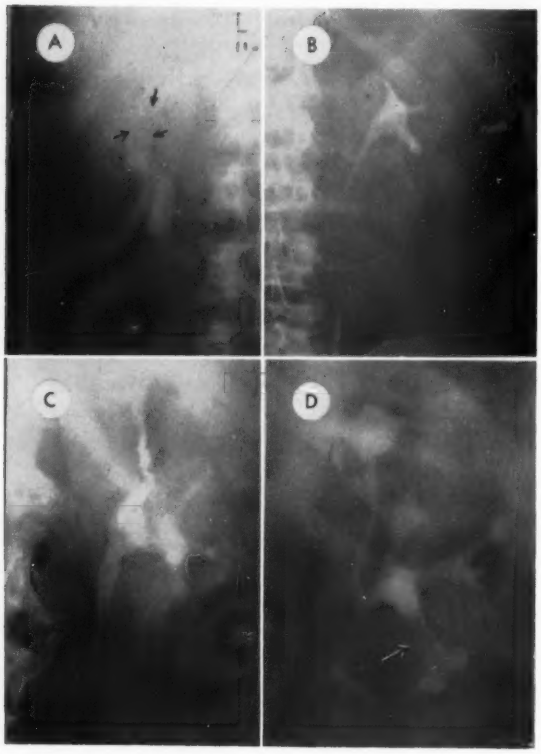


FIG. 1. (*A*) Solitary polypoid granuloma producing a filling defect in the upper major calyx. (Confirmed by operation.) (*B*) "Foam cell" granuloma of the left kidney causing compression of all major calyces and obliteration of the terminal calyces of the upper and lower major calyx. (Courtesy of Dr. B. S. Talbot.) (*C*) Ureteritis and pyelitis cystica associated with chronic pyelonephritis. The compression and elongation of the infundibula of the upper and middle major calyces and of all the minor calyces are due to chronic pyelonephritis. The cystic lesions of the upper ureter and pelvis are manifested as negative shadows. (Courtesy of Department of Radiology, Johns Hopkins Hospital.) (*D*) Localized hyperplastic cystic lesion in the infundibulum of the lower major calyx which is indicated by an arrow. (Confirmed by operation.)

trauma. Excretory and retrograde pyelography may fail to reveal any abnormality or the changes are so slight that they are easily overlooked.

2. *Specific Granuloma.* This is associated with tuberculosis and syphilis of the kidney and will be discussed later.

3. *Proliferative Solitary Polypoid Hyperplastic Granuloma.* This rare entity, previously undescribed, has recently been reported by one of the authors (B.S.A.). The polypoid tumor involved a single pyramid in the upper pole of the kidney (Fig. 1*A*). The tumor projected into and occluded the lumen of a terminal calyx producing a filling defect which simulated the appearance of a malignant tumor invading a terminal calyx.

4. *Pyelitis Cystica.* In an occasional case of chronic pyelonephritis, the response to the chronic infection is a severe hyperplasia of the mucosa and submucosa of a portion of the pelviocalyceal system. This may be manifested as a solitary cystic area within a calyx (Fig. 1*B*) or as diffuse small cystic changes (pyelitis cystica) (Fig. 1*C*) which produce a notched or punched out alteration of the pyelographic outline of the pelvis and less frequently of the calyces and ureter.

5. *Localized Hyperplastic Cystic Formation.* In rare instances, the hyperplastic process imparts the appearance of localized collections of granules or sand-like particles in the pelviocalyceal system—the so-called pyelitis granularis or granulosa. This does not produce any appreciable alteration of pyelographic outline of the affected area.

II. METAPLASTIC LESIONS

This type of lesion is extremely rare and is best exemplified by "foam cell" granuloma (xanthogranuloma) of which only 8 cases are reported. The tumor usually appears as one or more yellowish nodules of a buttery consistency varying in size from that of a cherry to that of a walnut and involving one or more pyramids, and occasionally extends to or beyond the corticomedullary line. The condition may be associated with chronic pyelonephritis, pyonephrosis and renal calculi. The pathologic changes are attributed to metaplasia of the fibroblasts of the medulla into foam cells. Some writers regard these changes as the first stage of a lipoid granuloma or of fatty replacement; others consider the process to be an early stage of sclerosing lipogranulomatosis. The pyelographic

changes associated with foam cell granuloma are not pathognomonic except when the process is confined to a pyramid and produces a calyceal dilatation or filling defect in the outline of the terminal calyx which may be confused with tuberculosis of a pyramid or papillary carcinoma of the terminal calyx (Fig. 1*B*). The correct diagnosis is made by pathologic examination of the removed kidney.

III. NONSPECIFIC INFECTIONS

1. *Pyelonephritis (acute, chronic, atrophic or focal varieties).* Pyelonephritis is not only the most common nonspecific infection of the kidney but also the most difficult to diagnose because of the manifold pathologic lesions and the wide variety of urographic changes produced by this disease which may be acute or chronic, unilateral or bilateral, and diffuse or localized. From a pathogenetic standpoint, the condition may be classified as ascending or descending, but not infrequently the pathologic features of both types may be present in the same case.

In the early stage of the ascending type, the pathologic changes are confined to the mucosal lining of the pelviocalyceal system and subsequently extend into the collecting tubules and interstitial tissue of the pyramids and finally extend into the adjacent parenchyma leading to fibrosis and scarring. A varying degree of contraction or dilatation of the pelvis and calyces is noted. The earliest urographic change is observed in the form of blunting or clubbing of calyceal cups with a minimal degree of pyelectasis (Fig. 2*B*). The outline of the pelvis and calyces reveals some diffuse irregularity due to changes in the epithelial lining of these structures which is absent in the noninfected obstructive uropathies (Fig. 2*A*). Later, widespread cicatrization occurs in the deeper layers of the pelviocalyceal system with destructive and necrotic lesions developing in the adjacent parenchyma which produces bizarre deformities of the pelvis and calyces, varying from irregular constriction or dilatation to partial or complete obliteration of one or more calyces (Fig. 2*C*).

The descending type is characterized by an acute, diffuse infection of the cortex and the contiguous structures. The urographic changes vary according to the severity and duration of the infection and seldom produce papillary or calyceal lesions except in the case of solitary abscess or carbuncle.

The end stage of both—the ascending and descending type of acute pyelonephritis—is the atrophic or contracted kidney of chronic pyelonephritis. Since the initial infection is usually bilateral, the atrophic or contracted kidney may develop on each side with variable degrees of involvement. The important retrograde pyelographic changes (Fig. 2*C*) associated with chronic pyelonephritis include (a) pyelectasis, (b) medial displacement of the pelvis, (c) caliectasis, (d) cicatricial deformities of the calcyes, and (e) ureterectasis. Delayed visualization of the pyelocalyceal system is an important finding in the excretory urograms.

Chronic focal pyelonephritis is the term employed by some authors to designate a localized type of chronic pyelonephritis in which the disease process is confined to one calyx and its adjacent papilla. The pathologic lesions associated with this type of infection may be manifested as one or more of the following lesions: (a) localized ulcerative or metaplastic lesions in the calyceal mucosa, (b) scarring in the submucosal layer producing calyceal deformities, (c) localized inflammatory, suppurative or destructive changes in a papilla appearing as an ulcerative necrotizing or hemorrhagic papillitis with or without extension into the corticomedullary and cortical zones, (d) localized cicatricial changes, and (e) abscess in the cortical and medullary areas with or without cavity formation. Many of these lesions are accompanied by severe, recurrent and uncontrollable hematuria. The urographic changes show considerable variation, from no demonstrable abnormality to a decided narrowing of the in-

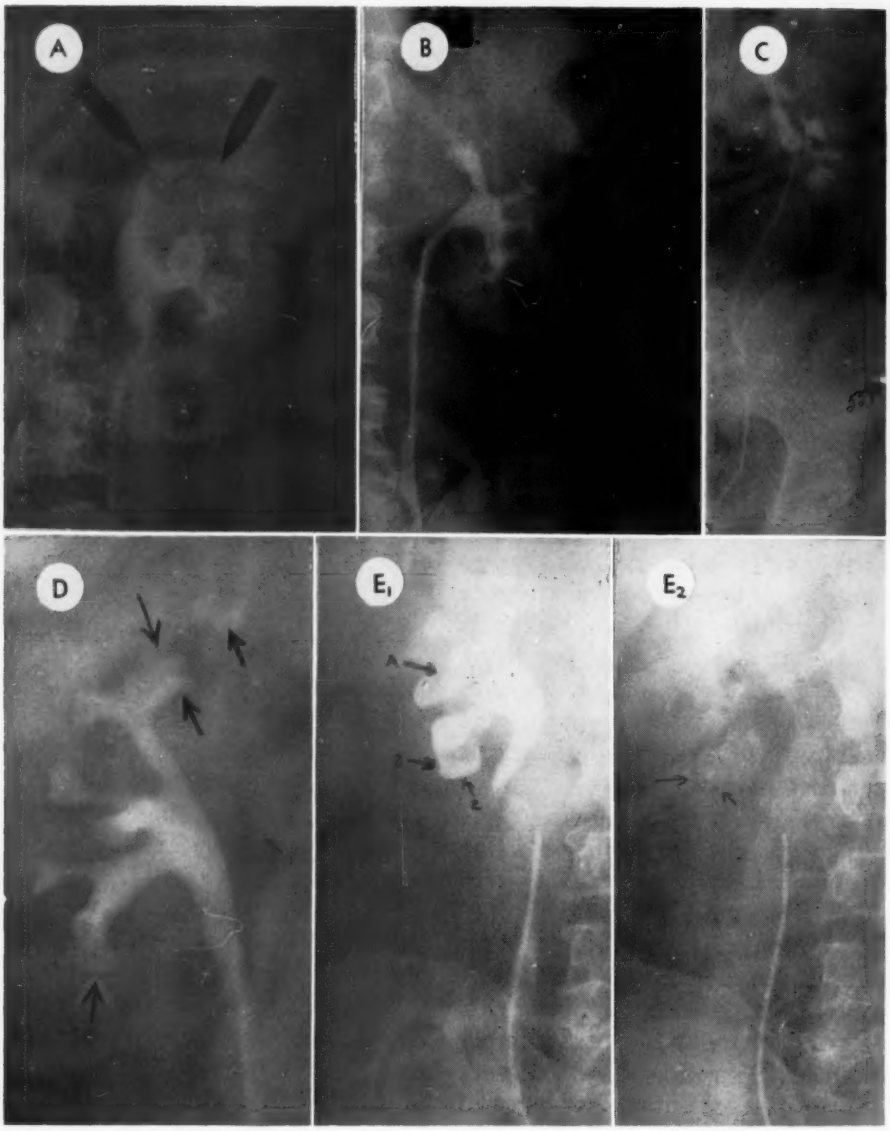


Fig. 2. (*A*) Acute suppurative pyelonephritis. The arrows point to obliterative changes in the outline of the terminal calyces caused by severe destructive lesions in the papillae. (Confirmed by operation.) (*B*) Partial obliteration of one of the terminal calyces of the lower major calyx caused by a focal type of acute pyelonephritis limited to one papilla. (Confirmed by operation.) (*C*) Chronic pyelonephritis with cystic changes in the cortical area. Note the bizarre contraction and distortion changes of all the major and minor calyces and the marked contraction of the pelvis. The displacement of the ureter is due to chronic inflammatory changes in the peripelvic and periureteral adipose tissue. (Confirmed by operation.) (*D*) Necrotizing papillitis associated with severe acute staphylococcal pyelonephritis involving the upper and lower minor calyces as indicated by arrows. (Confirmed by operation.) (E_1) Necrotizing papillitis associated with severe diabetes. The fuzzy outline of one of the papillae of the middle calyx is due to a diffuse infection of the papilla as indicated by arrow A. The marked alteration of the outline of the papilla of the lower major calyx is due to abscess formation and sloughing of the papilla. (Confirmed by operation.) (E_2) Same case. Pneumopyelogram showing outline of changes in calyces produced by necrotizing papillitis.

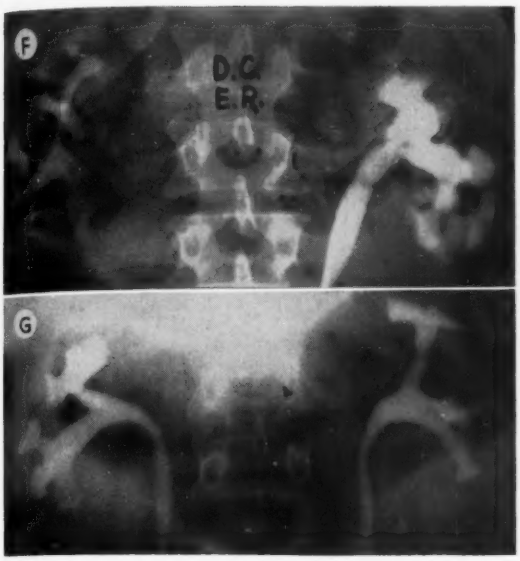


Fig. 2. (*F*) Bilateral chronic pyelonephritis with marked cystic changes in the cortical area. (Confirmed by autopsy.) (*G*) Chronic interstitial nephritis with marked contraction changes in the infundibula and terminal calyces. (Confirmed by autopsy.)

fundibulum or atonic dilatation of the terminal calyx when necrotizing or cicatricial changes have developed in the walls of the calyces. When the disease has produced serious changes in the architecture of a papilla (Fig. 2*D*), one or more of the following urographic changes may be observed, *viz.*, (a) filling defect, (b) fuzziness of the outline of the terminal calyx, and (c) pressure defect or cavity formation (Fig. 2*F*). Many of these cases have been reported as focal, hemorrhagic, or necrotizing papillitis, solitary abscess or carbuncle. It is our opinion that the chronic focal type of pyelonephritis is much more commonly encountered than the reports indicate.

Harlan recently reported 2 cases of chronic focal pyelonephritis accompanied by severe uncontrollable hemorrhage with positive urographic changes and requiring nephrectomy. The first case presented an irregular cyst-like dilatation in a solitary pyramid of the upper pole which was lined by glistening, hyperemic, fibrotic tissue and produced a filling defect in the outline of the terminal portion of the superior calyx in the retrograde pyelogram which was incorrectly diagnosed as a renal neoplasm. The second case presented a small submucosal hemorrhagic area (2 mm. in diameter) in the proximal portion of the superior middle calyx with a small blood clot attached. The hematuria in each instance resulted from the rupture of small capillaries in and around a pyramid.

2. *Hemorrhagic Papillitis.* This entity is responsible for severe intractable hematuria accompanied by little or no pain and a significant absence of positive urographic changes. In the past these cases were designated as "essential" or "idiopathic" hematuria until the correct diagnosis was established by careful pathologic study of the removed kidney. Nation has described the following histologic changes in one or more papillae, *viz.*, (a) hyperplasia and thickening of the mucosa of the minor calyces and pelvis, (b) small hemorrhages in the subepithelial tissues in the same area, (c) diffuse edema and leukocytic infiltration of the submucosal layer, (d) dilatation of the capillaries and venules in the same area, (e) hemorrhagic infiltration of the glomeruli and tubules, (f) deposition of small amount of blood pigments in the tubular elements, and (g) scarring in the cortical medullary zones. There is as yet no unanimity of opinion concerning the etiology and pathogenesis of hemorrhagic papillitis.

Urographic studies usually fail to reveal any abnormalities in the outline of the pelvis and calyces. However, Corbett reported a fuzzy irregularity in the outline of the superior calyx in one case and Nation observed a slight caliectasis, pyelectasis and marked irregularity in the outline of the ureter in one case.

3. *Necrotizing Papillitis.* This lesion was originally described by Frederich (1877) and has been variously called necrosis of the papillae or pyramids, papillitis necroticans, medullary necrosis, diphtheria of the pyramids, etc. It actually represents an unusual form of acute pyelonephritis occurring most frequently in diabetic individuals over forty years of age and less

commonly in nondiabetic patients suffering from some form of urinary obstruction complicated by an acute pyelonephritis. In diabetic patients, the condition is observed more frequently in females than males (2:1) but the reverse is true in nondiabetics (6:1). The condition is usually bilateral in females and unilateral in males. The clinical course is either acute or subacute.

The necrotic process involves all the papillae of the affected kidney and extent of necrosis varies with the severity and duration of the infection. In the early stages the lesion may appear as small abscesses confined to the tip of the papilla or situated in the central portion of the pyramid closer to the corticomedullary zone. Subsequently, the abscesses coalesce and cause complete necrosis of the papilla or pyramid. In the late stages, sequestration of the necrotic papillae may occur with sloughing out of the necrotic material.

Retrograde pyelography is of inestimable aid in establishing the correct diagnosis. The urographic changes (Fig. 2, E_1 and E_2) vary with the intensity of necrotic process and include (a) a deformity of the calyceal cup as in acute pyelonephritis, (b) irregular changes due to necrosis within the pyramid and extending to the corticomedullary zone with constriction of the infundibulum of the calyx, (c) ring shaped shadows in the necrotic papillae, (d) replacement of the concavity of the calyceal tip by blunting, rounding or dilatation of the calyceal cup, (e) cavity formation within the pyramid when the necrotic papilla sloughs away and is expelled and (f) dilatation of the pelvis or calyx due to obstruction by the sloughed papilla.

4. *Large Solitary Abscess of the Kidney.* This is a relatively uncommon condition characterized by a solitary abscess situated entirely within the renal parenchyma and not communicating either with the pelviocalyceal system or the perinephritic tissues. The etiology is an antecedent infection in the skin, teeth, tonsils, etc., with secondary hematogenous coccal emboli in the small terminal arteries of the kidney.

Important diagnostic aids are the pyelographic changes resulting from pressure of the abscess on the pyelocalyceal system. These changes include compression of the pelvis, separation of the calyces, and compression, distortion or displacement of a single calyx (Fig. 15, *C*). The first two deformities are particularly conspicuous when the abscess is centrally located and the latter change is most frequently noted when the abscess is located at either pole. The outline of the papilla or terminal calyceal cup is seldom altered or distorted in this condition unless the abscess compresses a calyx and prevents complete filling of calyx with the contrast medium. In such cases, the abscess may produce a crescentic deformity of the terminal calyx simulating a tumor or cyst or a filling defect suggestive of a tuberculous papillitis, hemorrhagic papillitis, blood clot or epithelial tumor. In rare cases, the solitary abscess may erode into and communicate with the pyelocalyceal system and the excretory or retrograde urogram will show an irregularity in the outline of the papilla and calyceal cup with irregular cavity formation which may simulate tuberculous cavity formation.

IV. SPECIFIC INFECTIONS

1. *Tuberculosis.* Renal tuberculosis presents many different clinical and pathologic aspects which may be attributed in part to the different degrees of virulence of the tubercle bacillus and in part to the different degrees of resistance and tissue reaction of the host. The pathologic changes of chronic surgical types of renal tuberculosis may be classified, *viz.*, caseocavernous, nodular, fibrotic and nonspecific.

In the caseocavernous type, the initial lesion may be found at the tip of the pyramid as an isolated minute yellowish tubercle surrounded by a small deep red inflammatory zone in the papillary epithelium. The lesion increases, by tuberculous granulation process, to pea size and spreads in the form of larger reddish brown plaques with scattered yellowish tubercles. Ulcer formation soon ensues as a result of

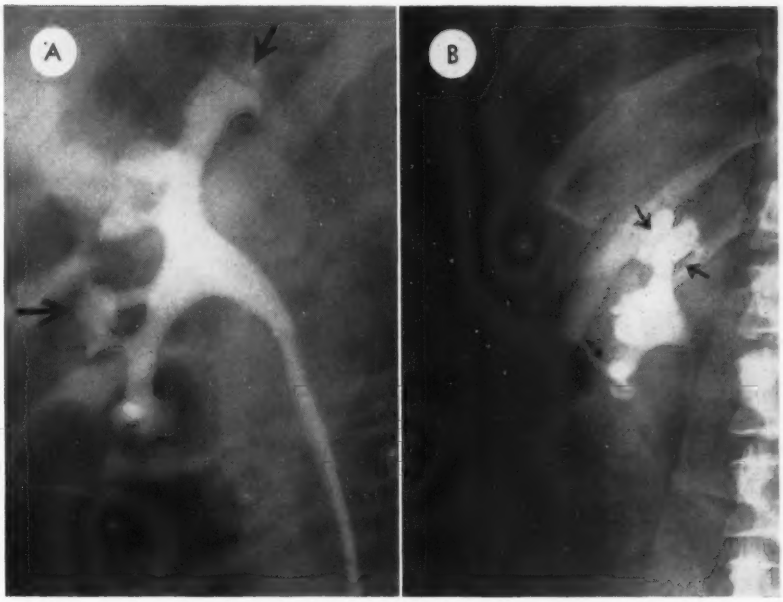


Fig. 3. (*A*) Early tuberculous lesions indicated by arrows and demonstrating fuzzy outline of the lower calyx and slight abscess formation in the upper calyx. (Confirmed by operation; no chemotherapy.) (*B*) Caseous lesions of the papillae indicated by arrows. (Confirmed by operation; no chemotherapy.)

necrosis, and the process invades the deeper layers of the epithelial lining and the papilla proper. In some cases the initial lesion appears to develop in the depths of the parenchyma, *i.e.*, at the base of the pyramid or in the cortex and undergoes considerable caseation before reaching the tip of the pyramid.

The urographic changes associated with the caseocavernous type include (a) absence or delayed visualization in excretory urograms, (b) calyceal or papillary necrosis, (c) cavity formation, (d) calyceal deformities, (e) caliectasis, (f) pyelectasis, (g) changes in outline and course of ureter, (h) calcification in the cortical or medullary areas, and (i) occlusive changes at the uretero-pelvic junction.

When the papillary tip or epithelium of terminal calyx is the site of the initial lesion the earliest pyelographic change will be manifested as a slight erosion of the outline of the tip of the papilla or calyceal cup as a result of ulcerative and necrotic changes in this area (Fig. 3*A*). Occasionally, one observes a minor degree of dilatation of the terminal calyx in these early cases. As the necrotic process spreads to deeper medullary zones with abscess formation, more distinct pyelographic changes are noted, *i.e.*, marked irregularity or moth-eaten appearance of the terminal calyx and cup, increased caliectasis, and distortions in the outline of the pyelocalyceal system (Fig. 3*B*). The extension of the tuberculous process to the deeper layers of the pyelocalyceal epithelium may result in cicatrization and stricture formation, particularly in the infundibular area of the calyces, and present a pinching-off defect.

The early erosive changes occurring at the tip of the papilla create the most difficult problems in differential diagnosis. They may simulate or be easily confused with necrotizing papillitis, pyelovenous and pyelo-interstitial backflow, hemangiomatous tumors of the calyx or pyramid, papillary carcinoma of the calyx or pyrmid, etc.

The nodular type is an uncommon finding and its pyelographic changes are extremely difficult to interpret.

The fibrotic type of renal tuberculosis is rare and is distinguished pathologically

from the nodular type by the absence or scarcity of tubercles. When the fibrotic changes are diffuse, they may lead to a contracted kidney, and when they are localized to one pole, the fibrotic area may attain considerable size. The rare type of tuberculoma reported by Bugbee and Benjamin belongs in the latter category and the pyelographic deformity of the terminal calyx and/or the pelvis associated with this type of lesion is more comparable to that produced by a renal tumor or cyst than by an infection. The diffuse fibrotic type of renal tuberculosis is always difficult to diagnose due to absence of tubercle bacilli in the urine, the bizarre pyelographic changes, and the absence of characteristic histologic changes in the removed kidney.

The diagnosis of renal tuberculosis should never be made solely on the basis of pyelographic changes in the outline of the pyelocalyceal system. The latter changes must be regarded only as presumptive evidence which must be substantiated by other clinical and laboratory data.

2. *Syphilis.* The paucity of reports of syphilis of the kidney in the past fifty years is a testimony of the efficacy of the early antileutic therapy with arsenicals or bismuth and the more recent therapy with the antibiotics. There are two main types of syphilitic infection of the kidney: syphilitic nephritis and gumma.

In the early stages of syphilitic nephritis, no pyelographic changes can be expected, but in the late stages with secondary atrophy, the pyelographic changes may be those of a diffusely contracted kidney. Gumma is regarded to be more common than syphilitic infection but is equally difficult to diagnose chiefly because the clinical symptoms (pain and gross hematuria), and the pyelographic findings are easily confused with a renal neoplasm.

V. CYSTIC LESIONS

1. *Serous Cyst.* Serous cyst may be classified as (a) superficial or (b) deep. The superficial type presumably originates in the outer portion of the kidney (cortex or corticomedullary zone) and may attain large proportion, producing compression changes in the adjacent calyces and pelvis (Fig. 4, *A* and *B*). The deep cyst may produce symptoms and pyelographic deformities which are easily confused with other papillary or calyceal lesions. The degree of calyceal or pelvic deformity produced by a deep cyst is directly related to its size and position. A moderate or large deep cyst usually produces compression changes limited to one calyx and may give the impression of the terminal portion of the calyx (*i.e.*, minor calyx) being stretched over a spherical body. When the deep cyst originates in the central portion of the kidney and increases in size, the compression and distortion changes involve more than one major calyx, and in extreme cases such a cyst appears to bisect the kidney in such a manner that the two poles of the kidney point inwardly toward the vertebra (Fig. 4*C*). The latter type also produces deformities in the outline of the pelvis as well as in the calyces. Calcification in the walls of the cyst are occasionally observed (Fig. 7, A_1 and A_2).

2. *Papillary Cyst.* This type was regarded by early writers as a "retention" cyst due to tubular occlusion by an inflammatory process but in reality must be considered as a small serous cyst of the deep intrarenal type.

3. *Pyelogenic Cyst.* This type, which was first described by Damm (1932), is also designated as a pyelogenous or peripelvic cyst. It is a small cyst (2 to 4 cm. in diameter) originating in the medullary portion of the parenchyma adjacent to and communicating with the pelvis or a major calyx by a narrow or pinpoint channel. This communicating channel is not always discernible on inspection but can be clearly demonstrated by excretory or retrograde pyelography. In rare instances, the opening between the cyst and the pyelocalyceal system may be obliterated by a chronic inflammatory process. This type of cyst is usually found at one of the poles and occa-

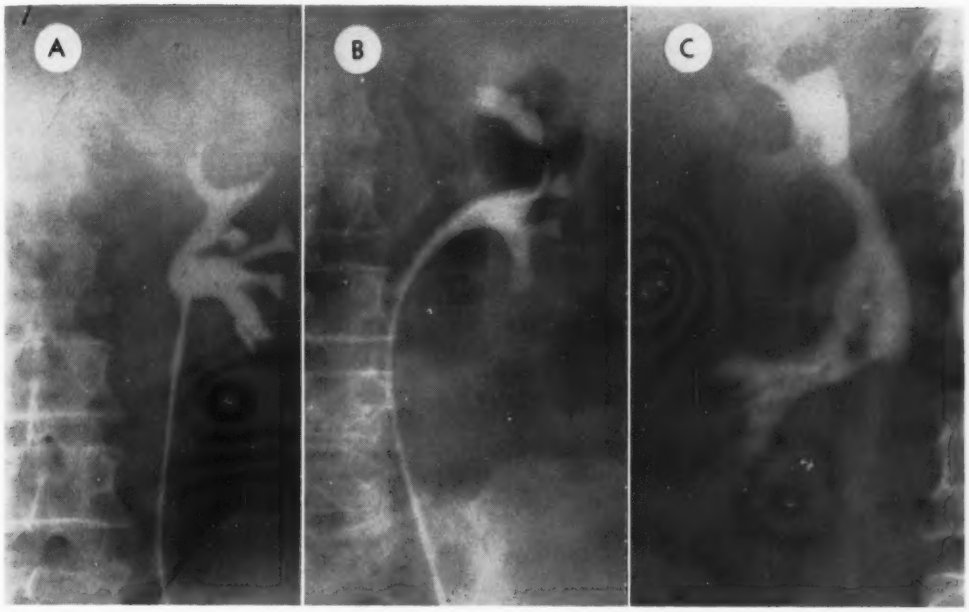


Fig. 4. (*A*) Solitary cyst of the superficial type involving one papilla in the upper pole. (Confirmed by partial nephrectomy.) (*B*) Solitary cyst of the superficial type involving one papilla and producing compression and distortion of the infundibulum and dilatation of the terminal calyx. (Confirmed by partial nephrectomy.) (*C*) Solitary cyst of the deep central type causing bisection of the kidney with compression and elongation of all major calyces. (Confirmed by operation.)

sionally may contain stones (Fig. 5*C*). The pyelographic defect produced in a calyx by this type of cyst is quite similar to that produced by a small deep intrarenal cyst. The cyst is usually asymptomatic, and its presence is detected during routine urographic study for other conditions.

4. *Calyceal Diverticulum.* This condition was first described by Prather (1941) as a small dilated cavity (about 2 to 3 cm. in diameter) which is always situated distal to the terminal or minor division of a calyx and is connected to this calyx by a narrow channel (2 to 6 mm. long and 1 to 2 mm. wide). The diverticulum can be clearly demonstrated by excretory or retrograde pyelography. The affected calyx fails to reveal any obstruction in the infundibular portion or at the tip of the affected papilla (Fig. 5*B*). The lesion may be congenital or acquired and is usually asymptomatic. Although both the calyceal diverticulum and pyelogenic cyst are lined by transitional epithelium, the former is distinguished by its location at the tip of a minor calyx and its characteristic communicating channel.

5. *Hydrocalyx.* This condition is essentially the dilatation of a single calyx and is easily confused with other lesions of the calyces and papillae. This type of cystic dilatation is always of acquired origin and the primary etiologic factors are (a) stricture or stenosis of the infundibular portion of the calyx by a chronic inflammatory process, (b) dysfunction or achalasia of the pyelocalyceal emptying mechanism and (c) calculi originating in the papilla or terminal calyx and often designated as encysted, cortical or parenchymal. They vary in size from 2 to 6 cm. in diameter and occasionally obtain a diameter of 10 cm. The overlying cortex is preserved in the early stages as the cavity increases in size; the parenchymal tissue surrounding the cavity becomes thin and even redundant in some cases. In an occasional case the natural communication between the calyceal cavity and the pelvis may become completely obliterated and it might be mistaken for a

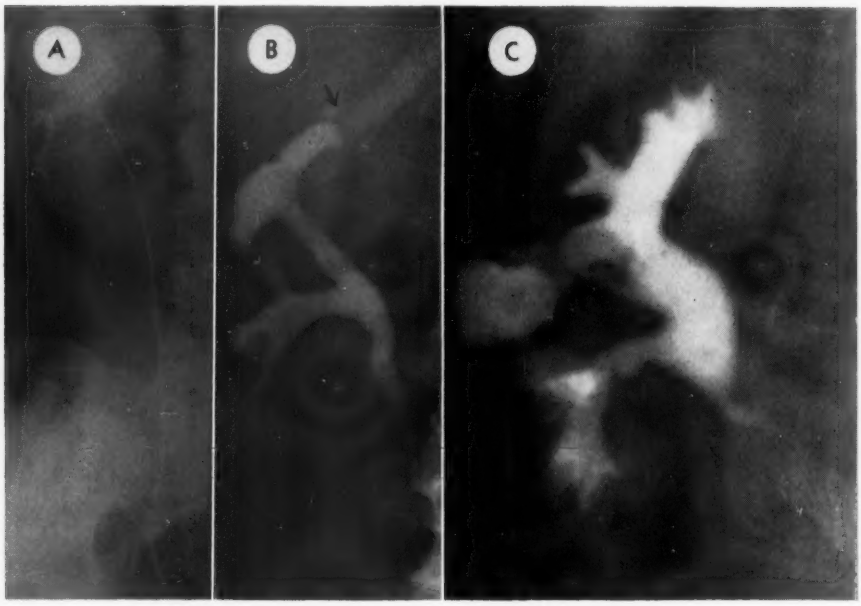


Fig. 5. (*A*) Peripelvic cyst of lymphatic origin producing displacement of the pelvis and compression changes in the pelvis and lower major calyx due to intrarenal extension of the cyst. (Confirmed by operation.) (*B*) Calyceal diverticulum attached to a minor calyx of the upper pole of the kidney. (Confirmed by operation.) (*C*) Pyelogenic cyst of the middle major calyx. Note the fine communicating channel connecting the cyst to the calyx as indicated by arrow. (Confirmed by operation.)

deep intrarenal or pyelogenic cyst (Fig. 13, B_1 and B_2). Hydrocalyx is usually accompanied by a dull or sharp pain in the kidney area, pyuria and a varying degree of hematuria.

6. *Multiple Small Cysts of the Pyramids.* This clinical and pathologic entity was first described by Cocchi and Ricca (1949) as a "sponge kidney" and independently by Vermooten (1950) as "congenital idiopathic dilatation of the collecting tubules." The distinguishing feature is the presence of multiple, small cavities in all of the pyramids of one or both kidneys which imparts a porous appearance to the affected kidney. The outstanding clinical features are pain of a colicky nature, fever, pyuria and hematuria. The pyelographic changes are permanent and persist over years with relatively little increase in size (Fig. 6, *A*, *B* and *C*). The chief findings are compression or distortion of the terminal portion of the calyces produced by small medullary cysts. In addition, clumps of small opaque grape-like shadows are seen when the cysts contain calculi. This latter condition is often regarded as a form of nephrocalcinosis.

7. *Peripelvic Cyst.* This type of cyst is usually found adjacent to and extending along the renal pelvis into the renal parenchyma and produces an alteration in the outline of the pelvis and one or more calyces (Fig. 5*A*). It is presumably due to an obstruction to the lymphatics draining the pelvis and calyces.

8. *Echinococcus Cyst.* This type of cyst is rarely observed in this country. It is always associated with echinococcal disease elsewhere in the body. The pathologic lesion consists of a large mass occupying one of the poles of the kidney composed of multiple daughter cysts. The cystic mass compresses and destroys the adjacent parenchyma. The pyelographic findings vary with the size of the cystic mass and usually reveal compression changes in one or more calyces and distortion of the pelvis (Fig. 7*B*).

9. *Polycystic Disease.* This congenital cystic disease is usually bilateral (Fig. 7*C*) and, only in rare instances, unilateral

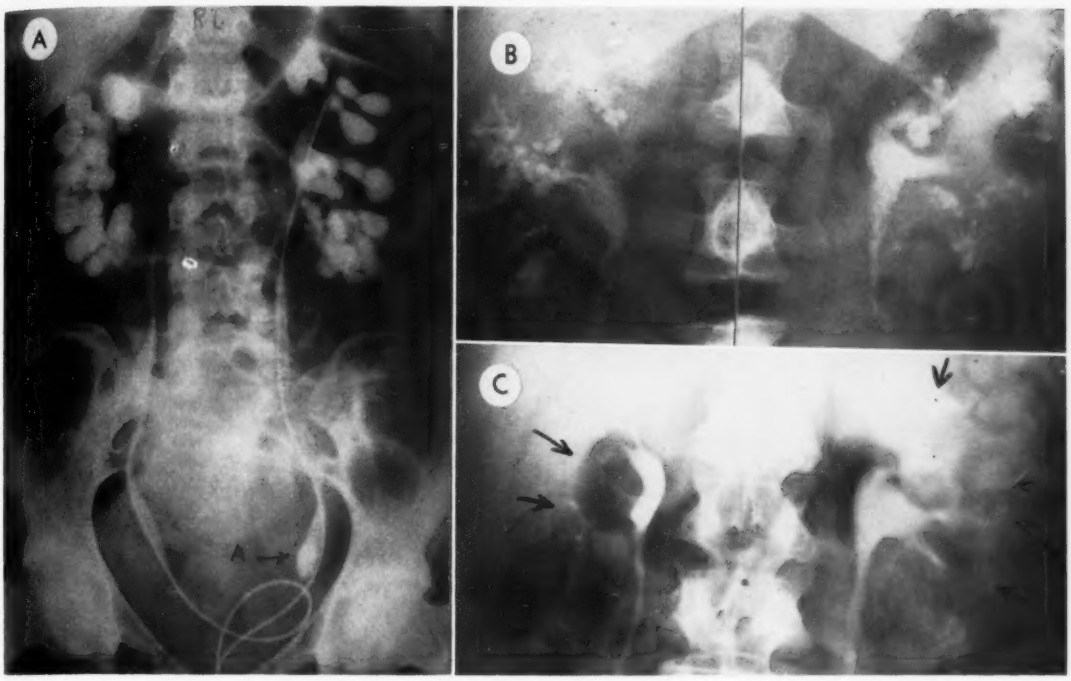


FIG. 6. (*A*) Bilateral multiple calculi in "sponge kidneys" in a case of renal rickets. (Confirmed by autopsy.) The calculi appear in each papilla resembling a cluster of "grapes." The arrow A indicates a cluster of stones in the lower end of the left ureter. (*B*) "Sponge kidney" with minute calculi occupying the cystic lesions of all papillae of both kidneys. (Courtesy of Department of Radiology, Johns Hopkins Hospital.) (*C*) "Sponge kidney" with minute calculi occupying the cystic lesions of the papillae of both kidneys. (Confirmed by removal of left kidney.)

(Fig. 7*D*). The characteristic pyelographic changes are (a) "spider leg" elongation of all major calyces, (b) compression, elongation, distortion or dilatation of the minor calyces, (c) compression, distortion, elongation or dilatation of the pelvis, (d) right angulation of ureter at ureteropelvic junction, and (e) downward displacement of entire kidney by cystic mass.

VI. BENIGN TUMORS

1. *Adenoma.* Small adenomas situated in the cortical zone are asymptomatic and produce no pyelographic defect. The large adenomas are occasionally situated at one pole of the kidney and may produce pyelographic changes that may be difficult to distinguish from those caused by a malignant neoplasm or by a deep intrarenal cyst compressing one calyx (Fig. 8*A*). In rare instances, calcification may be present within the adenoma (Fig. 8, *B* and *C*).

2. *Lipoma in and about the Kidney.* Intrarenal and extrarenal fatty tumors are rare entities which are seldom diagnosed preoperatively. They may be classified, *viz.*, (a) perirenal lipoma, (b) intrarenal lipoma, and (c) replacement lipomatosis. Perirenal lipoma originates in the perirenal fat and does not produce any change in the outline of the pyelocalyceal system but causes a displacement of the kidney on its longitudinal or transverse axis.

Intrarenal lipoma apparently originates from embryonic connective tissue surrounding the tubules and pyelocalyceal system and consequently, may encroach upon any portion of the pyelocalyceal system but is more prone to impinge upon the pelvis or a terminal calyx. This tumor produces a sharp punched out filling defect in the affected portion of the pyelocalyceal system (Fig. 8*D*).

Replacement lipomatosis is not a true tumor but an intrarenal accumulation of fat in a loose fibrous stroma outside the pyelo-

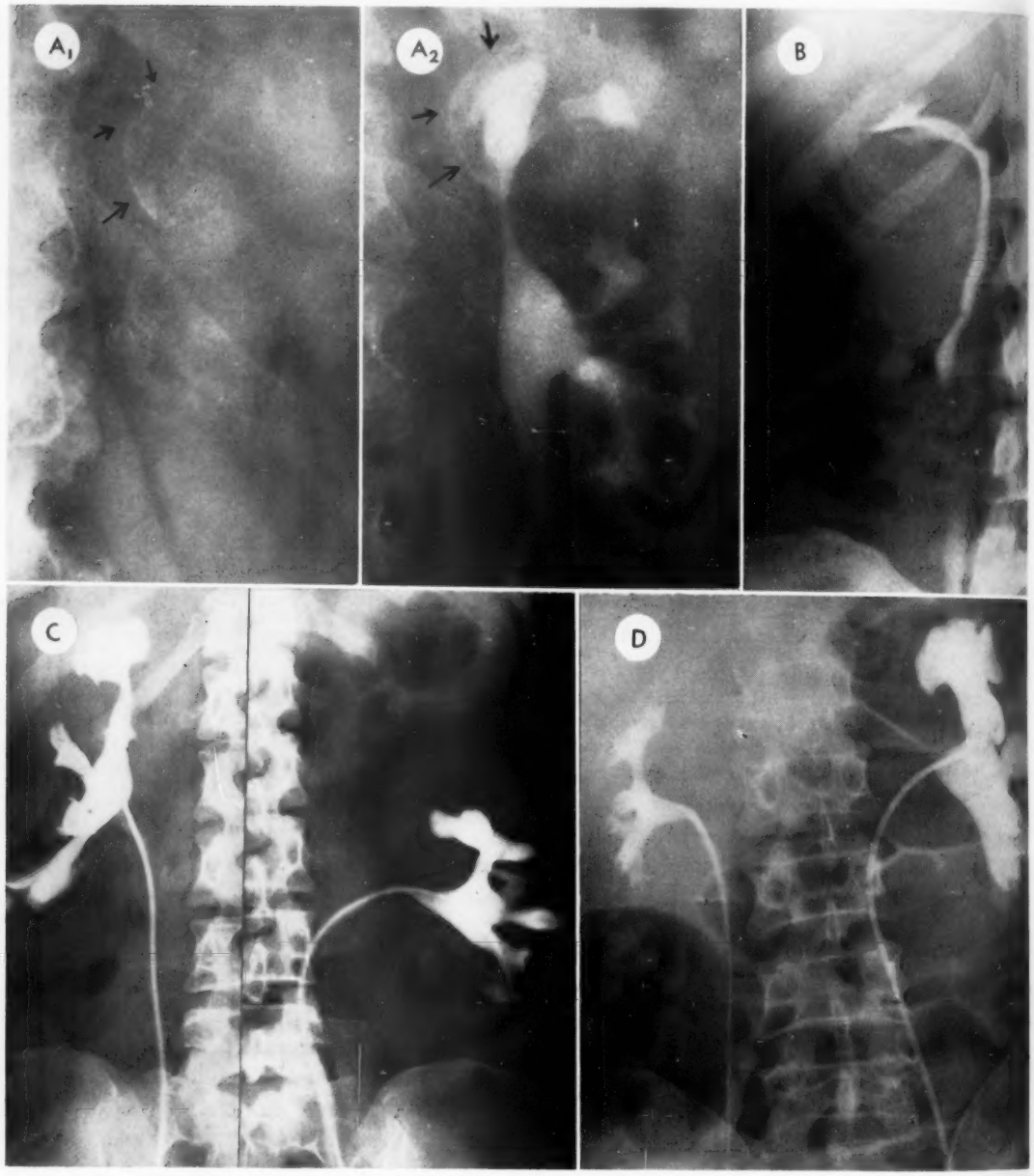


FIG. 7. (A_1) Area of calcification in the upper pole of the left kidney. (A_2) Same case after retrograde pyelography showing the calcification to be in a cyst of the upper pole which has compressed and distorted the terminal portion of the upper major calyx. (Confirmed by operation: Courtesy of Department of Radiology, Johns Hopkins Hospital.) (*B*) Echinococcus cyst of the lower pole of the right kidney causing displacement and compression of the upper two major calyces, pelvis and ureter. (Confirmed by operation; courtesy of Dr. Wm. Baurys.) (*C*) Bilateral congenital polycystic disease. Note the typical "spider leg" deformity of all major and minor calyces of the right kidney and the right angulation of the left ureter at the ureteropelvic junction. The pyelographic changes in all terminal calyces produced by the diffuse cystic disease are characteristic. (Confirmed by operation.) (*D*) Unilateral congenital polycystic disease of the left kidney showing right angulation of the ureter at the ureteropelvic junction, medial displacement of the kidney, and dilatation and compression of all calyces due to cystic lesions. (Confirmed by operation and by repeated pyelographic studies over a fifteen year period.)

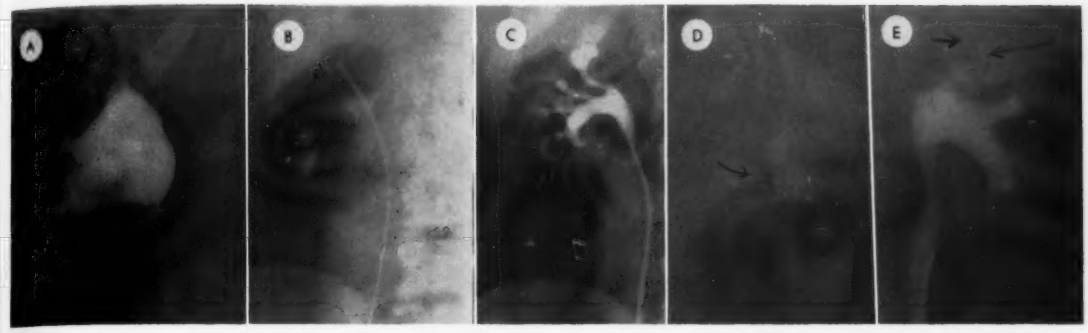


Fig. 8. (*A*) Adenoma involving the upper pole of the right kidney with marked compression and obliteration of the upper calyx. (Confirmed by operation: Courtesy of Department of Radiology, Johns Hopkins Hospital.) (*B*) Plain roentgenogram showing a round calcified shadow in the region of the lower pole of the right kidney. (*C*) Same case, showing calcified shadow adjacent or adherent to one of the terminal calyces of the lower pole. At operation a calcified adenoma was found. (*D*) Intrarenal lipoma producing a marked notching of the outline of the pelvis. (Confirmed by operation.) (*E*) Leukoplakia of the upper major calyx with obliteration of the outline of the papilla. (Confirmed by operation.)

calyceal system. It is usually unilateral and appears to replace the renal parenchyma destroyed by an inflammatory, atrophic, vascular, or necrotic process which serves as a precursor of the fat replacement. Renal calculi and chronic pyelonephritis are present in about 80 per cent of the cases. In the majority of cases, the fat replacement appears to encroach upon the pelvis and/or the calyces without actually invading those structures. In about 60 per cent of the reported cases in which pyelography was performed, definite defects and deformities were observed in the pyelocalyceal system as evidenced by either distortion, displacement, compression and partial obliteration of the pelvis or one or more calyces (Fig. 15*B*).

3. *Fibroma.* This uncommon tumor is regarded by many pathologists as a hamartoma. It is most frequently found to be subcapsular in position but occasionally is adjacent to or projecting within the pelvis or calyces. Immergut and Cattler reported a pedunculated intrapelvic fibroma causing hematuria and producing a mottled dilated pelvis with a filling defect in the pyelocalyceal system.

4. *Hamartoma.* This is also a rare tumor of the renal parenchyma composed of mixed tissue elements, *i.e.*, smooth muscle, connective tissue and fat. It apparently arises from aberrant anlagen, *i.e.*, fetal nests of cloacal tissue, but is not a true teratoma. Some writers believe there is a relationship between this tumor and tuberous sclerosis. This tumor produces no clinical symptoms or pyelographic changes unless it attains a large size as in Rusche's case when it is indistinguishable from a large benign or malignant tumor (Fig. 8*C*).

VII. MALIGNANT TUMORS

1. *Adenocarcinoma.* Malignant neoplasms originating in the parenchyma of the kidney must be considered in the differential diagnosis of papillary and calyceal lesions because, as these tumors increase in size, they assume various configurations and produce bizarre pyelographic deformities. Small neoplasms may be so situated that they do not encroach upon nor distort the pyelocalyceal system. Large neoplasms produce a wide variety of pyelographic changes, no one of which is absolutely typical or pathognomonic. The most common changes involving the calyces are (a) elongation and compression of one or more calyces (Fig. 9*A*), (b) abnormal changes in the outline of the terminal portion of the minor calyces (Fig. 9*B*), and (c) partial or complete obliteration of one or more calyces (Fig. 9*C*).

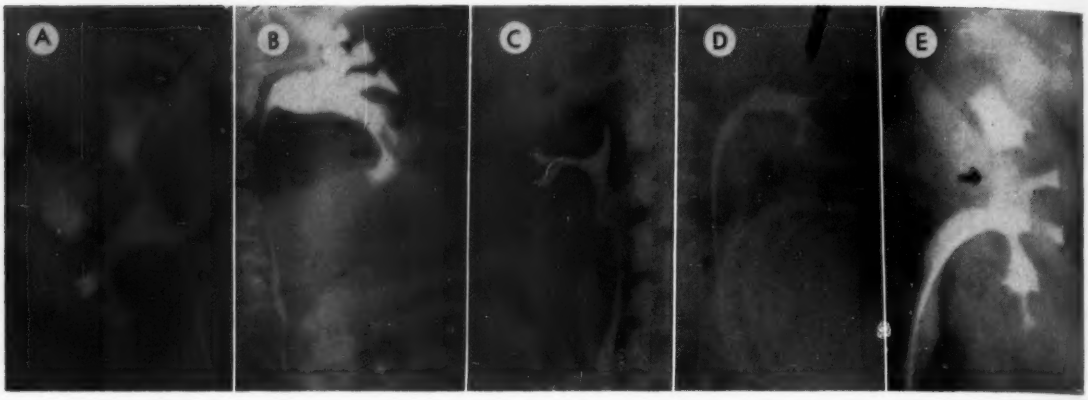


Fig. 9. (*A*) Small hypernephroma of the upper pole of the right kidney producing distortion and elongation of the minor calyx. (Confirmed by operation.) (*B*) More advanced hypernephroma of the lower pole of the left kidney showing incomplete filling and compression, elongation and distortion of the lower major calyx. (Confirmed by operation.) (*C*) Advanced hypernephroma of the right kidney showing marked elongation, compression and partial obliteration of the upper calyx. (Confirmed by operation.) (*D*) Large hypernephroma completely obliterating the upper major calyx. (Confirmed by operation.) (*E*) Hypernephroma of the upper pole of the left kidney with finger-like projection into the pelvis indicated by arrow. (Confirmed by operation.)

As the tumor continues to grow, the architecture of the affected calyx and its adjacent pyramid becomes grossly distorted. The calyceal cupping surrounding the tip of the pyramid may appear blunted, narrowed, tapered, bulbous, or partially or completely obliterated. In some instances, the terminal portion of the calyx is poorly visualized or impossible to fill by retrograde pyelography (Fig. 9*D*) because of compression of the calyx by the tumor but can be demonstrated by excretory pyelography or vice versa.

In an occasional case, a portion of the tumor may extend as a finger or knob-like projection into one of the calyces or into the pelvis (Fig. 9*E*) and produce a filling defect not unlike that caused by a polypoid or foam cell granuloma, an epithelial or vascular tumor of the terminal calyx, a blood clot, or a nonradiable calculus. However, in the former type, the presence of

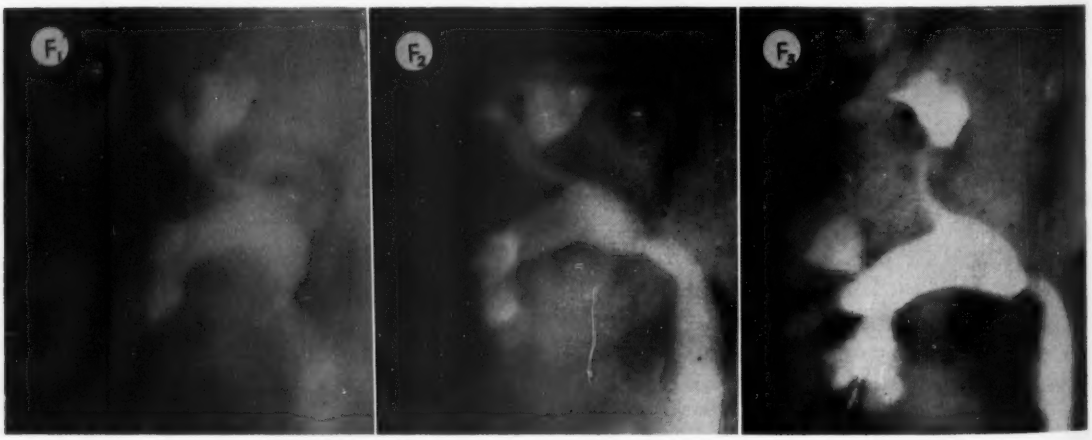


Fig. 9. (F_1) September, 1925. Hypernephromatous metastasis to the upper pole of the right kidney nine months following removal of hypernephroma of the left kidney. (F_2) April, 1931. Progressive destruction of the upper pole of the right kidney six years after removal of the left kidney. (F_3) April, 1934. Progressive changes in the upper major calyx nine years after removal of the left kidney. (Confirmed by autopsy.)

other pyelographic changes, *i.e.*, deformities in the pelvis and calyces, alterations in the kidney outline, displacement of the kidney, etc., are of great value in establishing the correct diagnosis, but in rare instances, the latter changes may be absent or difficult to discover.

2. *Epithelial Neoplasms of the Pyelocalyceal System.* Primary epithelial tumors may occur in any portion of the pyelocalyceal system and originate in the transitional epithelium. They are essentially of two types, (a) papillary, *i.e.*, papilloma, papillary carcinoma, and (b) nonpapillary or solid, *i.e.*, epithelioma. They vary in size from a minute tumor producing no clinical and pyelographic changes to an extensive tumor filling the entire pelvis, calyces, ureter and even penetrating the parenchyma.

The pyelographic changes depend upon the size, type and location of the growth. The most striking pyelographic finding is the presence of a filling defect in the pelvis resulting from displacement or obstruction of the injected contrast medium (Fig. 10*A*). This defect may be clearly defined when the tumor is of the solid type (Fig. 10*D*) or it may appear mottled and irregular when a papillary tumor is present. When the tumor occludes the pelvis or calyx or both, dilatation of the corresponding area results, *i.e.*, pyelectasis, caliectasis.

In an occasional case of papillary carcinoma beginning in the infundibular or terminal portion of a calyx, one may observe an alteration in the outline of the terminal portion of the calyx which may be easily confused with either a tuberculous papillitis or necrotizing papillitis (Fig. 10*B*). Filling defects in the infundibular portion or in the terminal calyx may be caused by the tumor *per se* or by accompanying blood clots.

VIII. VASCULAR TUMORS

These tumors are responsible for hematuria, pain, vesical dysfunction and pyelographic changes. They may be classified: (1) *benign* (*i.e.*, capillary, plexiform and cavernous hemangioma) and (2) *malignant* (*i.e.*, hemangiosarcoma and hemangioblastoma) derived from blood or lymph vessels. In the same general category, one must also include a varix situated at or near the tip of a papilla which is not a true tumor but a dilatation of a pre-existing vein or group of veins (telangiectasis).

The pyelographic changes induced by these vascular lesions are not constant or characteristic. The varix or capillary hemangioma may produce a defect limited to the tip of a pyramid or adjacent fornix (Fig. 10*C*) which is difficult to distinguish from the changes produced by papillary erosion or necrosis or papillary tuberculosis. Plexiform or cavernous hemangioma or hemangiobalstoma are more prone to produce more serious and obstructive changes in the parenchyma or alterations in the shape and outline of the pelvis and calyces like pyelectasis and caliectasis.

IX. MISCELLANEOUS LESIONS

1. *Nonradiable Calculi.* It has been estimated that approximately 5 to 8 per cent of urinary tract calculi are nonradiable. These nonopaque calculi are of two types, *viz.*, (a) organic, *i.e.*, cystine, xanthin, leucine, cholesterol, sulfonamide, bacterial, albumin, fibrin, etc., and (b) inorganic, *i.e.*, uric acid, urate and soft calcium stones. The most common type is the uric acid calculus. Approximately 10 to 20 per cent of the patients with gout suffer from uric acid calculi (Fig. 11, *A* and *B*).

These nonradiable calculi may be found in any part of the urinary tract but are most frequently situated in the ureter or in the pelvis. Occasionally, they are located in the infundibular and terminal portion of the calyx where they may be responsible for negative shadow or filling defect (Fig. 12*B*) which is easily confused with a specific or nonspecific papillitis, blood clot, air bubble, inspissated pus, benign hyperplastic lesion of the calyceal membrane, papillary carcinoma or vascular tumor at or near the papillae. However, when these calculi become firmly fixed or lodged for a long period

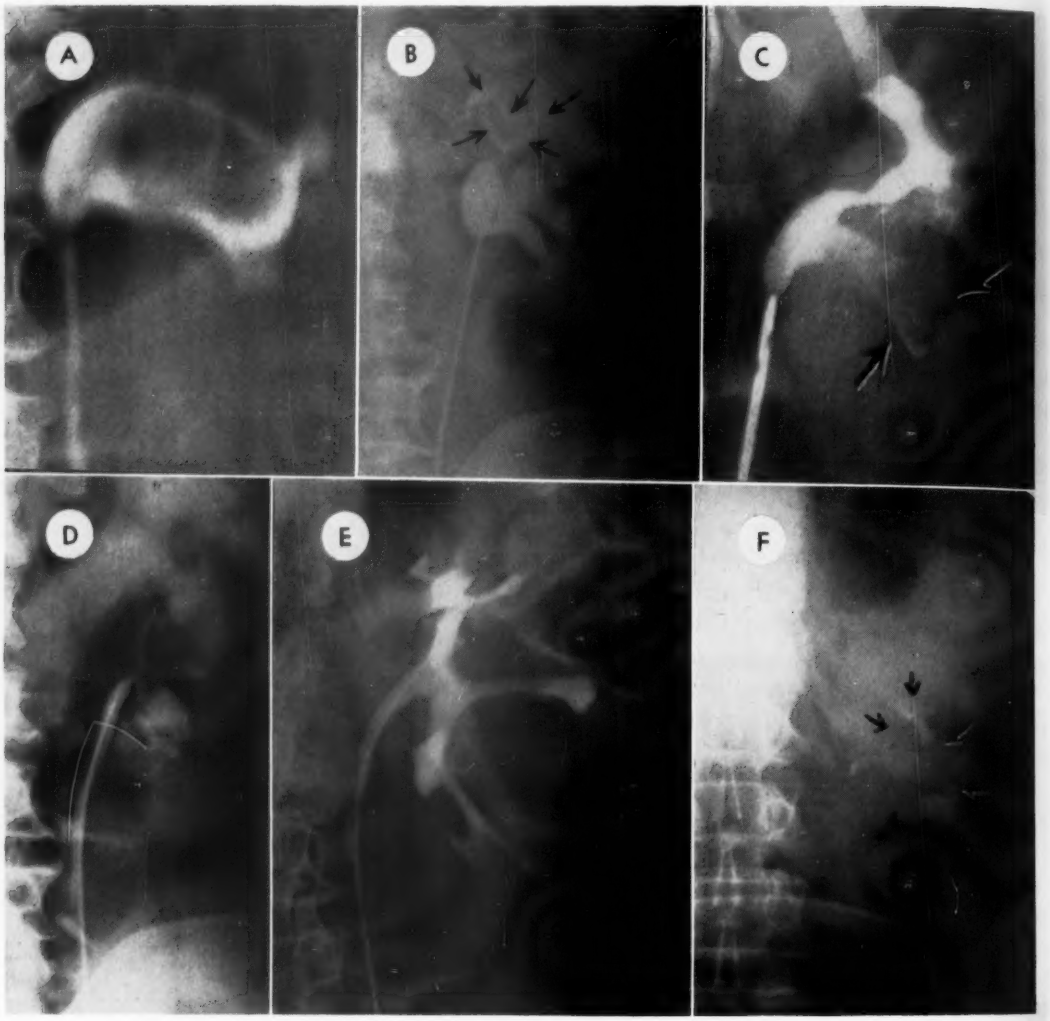


Fig. 10. (*A*) Papillary carcinoma of the renal pelvis producing a filling defect indicated by the negative shadow. (Confirmed by operation.) (*B*) Papillary carcinoma of the upper calyx of the left kidney producing a filling defect and broadening of the terminal calyx. (Confirmed by operation.) (*C*) Angioma of the lower calyx of the left kidney causing filling defect. (Confirmed by operation.) (*D*) Squamous cell carcinoma involving the lower major calyx and producing a mottled filling defect. (Confirmed by operation.) (*E*) Lymphosarcoma of the left kidney showing marked elongation, distortion, and obliteration of the lower and middle calyces. (Confirmed by operation.) (*F*) Lymphosarcoma of the left kidney with diffuse involvement of the entire kidney and resulting in irregular filling defects of all calyces. (Confirmed by operation.)

of time in the infundibular or terminal portion of the calyx they are prone to produce a hydrocalyx or localized caliectasis which may be readily discernible on excretory or retrograde pyelograms (Fig. 13, B_1 and B_2). Not infrequently the contour and density of radiable and nonradiable calculi are such that they produce a mottled or irregular shadow (Fig. 12, A_1 and A_2) which may be mistaken for a localized area of tuberculosis, ulceration, or abscess with little or no calcification.

2. *Deposition of Crystalloids in the Papillae and Pyramids.*

a. Calcium infarcts in the pyramids. These calcium deposits, which are composed of calcium carbonate or phosphate, appear to involve all the pyramids of both kidneys and are frequently designated as calcinosis or nephrocalcinosis. The condi-

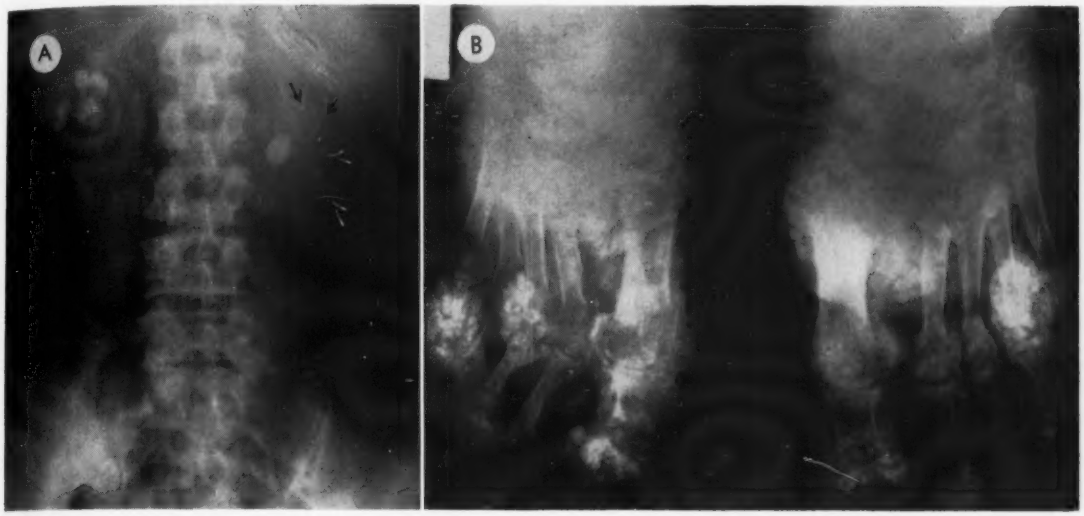


FIG. 11. (*A*) Uric acid calculi in both kidneys and uric acid infarcts of the left kidney indicated by arrows. (*B*) Roentgenogram of both feet in same case showing extensive periarticular infiltrations of uric acid.

tion may be observed in any disease accompanied by marked hypercalcemia.

The urographic pattern is clearly discernible on the plain roentgenogram as the calcium salts appear as white brush-like radiations at the tip of all the papillae and extend into the depths of the pyramids.

b. Uric acid infarcts. These lesions are frequently observed in the kidneys of infants and children and rarely in adults. The infarcts produce a yellow streaking of the papilla of the pyramid and are sometimes accompanied by actual stone concretions embedded in ragged cavities at or near the tip of the papilla. These deposits in the tubules of the papillae do not cast a shadow in the plain roentgenogram but may produce a fuzzy irregularity in the outline of the papillae in the retrograde pyelograms.

c. Urate infarcts. Deposits of urate crystals in and between the tubules of the pyramids are occasionally observed in

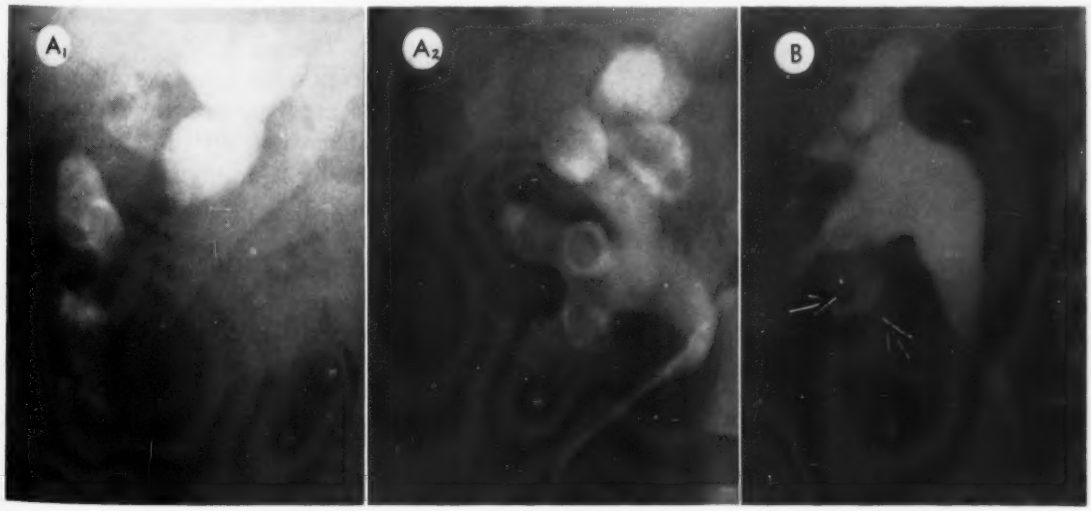


FIG. 12. (A_1) Plain roentgenogram revealing numerous calculi in the terminal calyces. (A_2) Same case, showing negative shadows produced by calculi in the terminal calyces. (*B*) Incomplete filling defect in the lower calyx produced by a nonradiable calculus. (Confirmed by operation.)

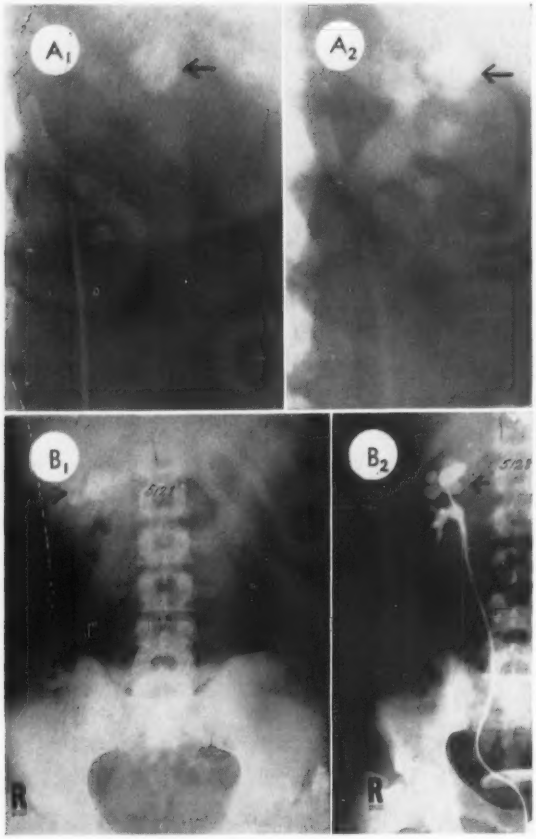


Fig. 13. (A_1) Plain roentgenogram showing encysted cortical stone. (A_2) Pyelographic appearance of encysted cortical stone. The cystic lesion may have been a calyceal diverticulum. (Confirmed by partial nephrectomy.) (B_1) Plain roentgenogram showing a cluster of calculi in the upper pole of the right kidney. (B_2) Same case. Localized calculous pyonephrosis of the upper major calyx. (Confirmed by operation.)

severe cases of gout. These deposits appear as white chalky striations in the tips of the papillae and usually involve all the pyramids of both kidneys to a variable degree. As a rule, the urate infarcts of the papillae are not discernible on the plain roentgenogram except in severe cases of gout with extensive infarct formation. Slight irregularity of the outline of the terminal calyces may be present in the retrograde pyelogram in cases with extensive infarct formation.

d. Microlithiasis and calcareous plaques. In 1926 Lichtenstein described calcium deposits attached to the renal parenchyma and projecting into the lumen of the calyx which he designated as microlithiasis. In 1938 Randall associated calcium infarcts with the formation of renal calculi.

These microliths and calcium plaques are not discernible on the plain roentgenogram. When these plaques attain a considerable size, they may produce slight irregularities in the outline of the calyceal cup which are difficult to detect or may be obscured by the contrast medium.

e. Sulfonamide infarctions. Renal complications of sulfonamide therapy rarely are seen today with the newer sulfonamide compounds and combinations of this group of drugs.

The pyelographic changes encountered were varied and bizarre, depending upon the degree of precipitation of the sulfonamide crystals within the calyces, pelvis, and ureter. Filling defects with the pyelocalyceal system were frequently noted.

3. *Renal Infarction and Embolism.* Renal infarction occurs more frequently than the reports would indicate. As a rule, this type of lesion is encountered in individuals past the age of fifty when vascular diseases and accidents are more prone to occur. The area of infarction in the kidney is most frequently confined to the cortical zone but may include or be limited to a pyramid depending upon the size and location of the blood vessel occluded.

Renal infarction of arterial origin is the type most commonly encountered and may be partial or complete in the extent of its involvement of the kidney. Infarction due to venous obstruction is less frequently observed but far more serious in its effect. Traumatic infarction is the rarest type.

The outstanding clinical symptoms are sudden sharp pain in the affected kidney area and hematuria which may be masked or overlooked as attention is focussed on the serious cardiac, vascular, or traumatic lesion responsible for the renal infarction. The pyelographic changes associated with renal infarction or embolism vary with the extent of the infarcted area. The distortion and defects in the outline of the pelvis and

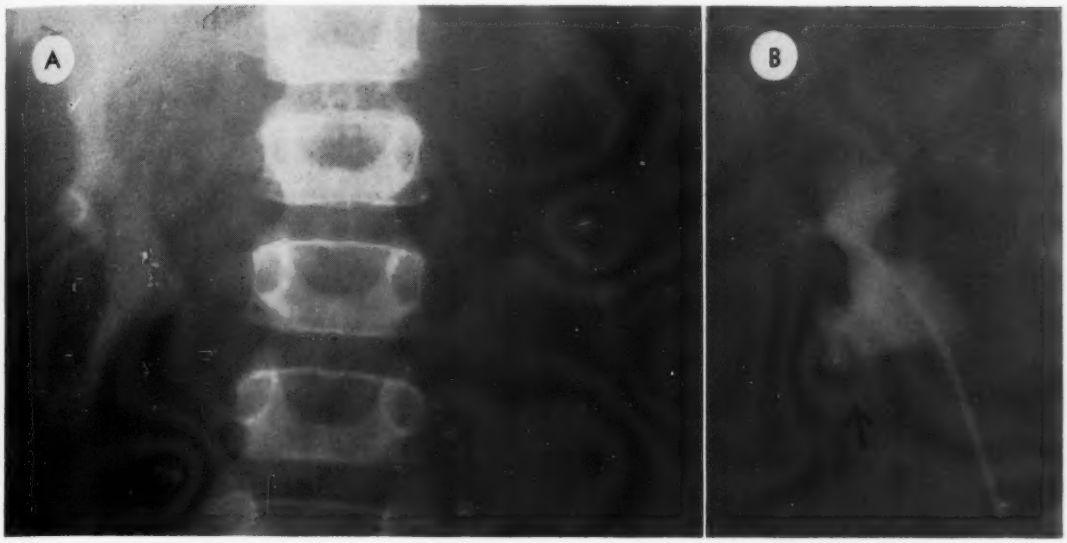


FIG. 14. (*A*) Acute lymphoblastic leukemia with diffuse involvement of both kidneys and compression of the calyces. (Courtesy of Department of Radiology, Johns Hopkins Hospital; confirmed by autopsy.) (*B*) Localized infiltration of the lower pole of the right kidney in a case of acute lymphatic leukemia. (Confirmed by partial nephrectomy.)

calyces associated with renal infarction and embolism are often misinterpreted or incorrectly diagnosed as the more familiar renal diseases. Inasmuch as these lesions of the kidney may be accompanied by serious impairment in renal function, the pyelographic changes are more clearly demonstrated by retrograde than by excretory urographic studies.

4. *Leukoplakia.* This specific lesion is usually found in the renal pelvis but may be localized to one calyx. It is usually associated with a chronic irritative process, *i.e.*, calculus. The leukoplakic area may be represented by a motheaten filling defect in the pelvis or calyx in the excretory or retrograde pyelogram (Fig. 8*E*).

5. *Malacoplakia.* Malacoplakia is a peculiar granulomatous lesion which is most commonly found in the bladder but in exceptional cases may involve the ureter and pelvis of the kidney. These granulomatous lesions form multiple, discrete round masses or plaques, seldom exceeding 1 cm. in diameter. The pyelographic changes are essentially a filling defect caused by the small nodules.

6. *Lesions Associated with Diseases of the Hemopoietic System.* Acute lymphatic and myeloid leukemia not infrequently produces secondary lesions in the kidney which may be the cause of death, especially in young people. These secondary lesions are present in the form of leukemic infiltrations of the interstitial tissue of the cortical and corticomedullary zones and occasionally extend down into the pyramids of the medulla (Fig. 14*A*). These leukemic infiltrations may also be accompanied by intratubular hemorrhages and submucosal hemorrhage in the pelvis and calyces.

Urographic changes are difficult to discern when the infiltration is confined to the cortical and corticomedullary zones. Positive urographic changes may occur when the pyramid is involved and the swollen papilla projects into and obstructs the lumen of the terminal calyx or when blood clots accumulate at the tip of the papilla or occlude the pelvis or calyx (Fig. 14*B*).

7. *Metastatic Tumors.* Lymphosarcoma and lymphoblastoma are extremely rare primary tumors of the kidney but occasionally produce secondary lesions in the kidney either as a result of metastases or by direct invasion from a neighboring focus. These

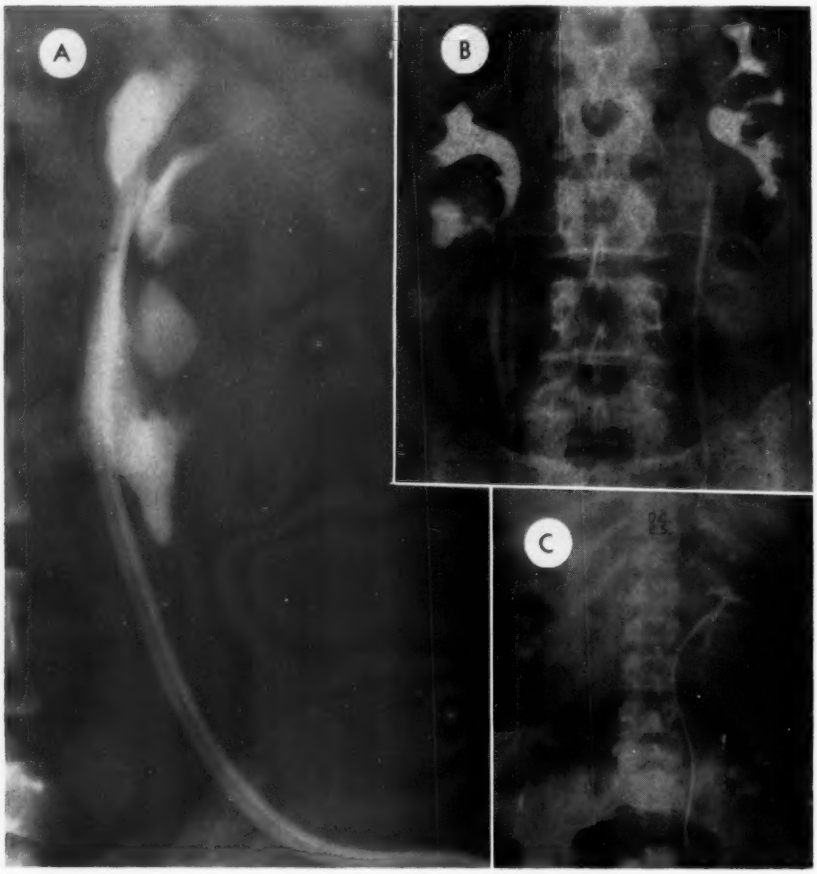


Fig. 15. (*A*) Perirenal hematoma causing medial displacement and rotation of the kidney and ureter. The compression changes involving the terminal calyces were due to chronic pyelonephritis. (Courtesy of Department of Radiology, Johns Hopkins Hospital.) (*B*) Replacement lipomatosis of both kidneys, more marked in the right than the left kidney. Note compression and distortion of the lower calyx and pelvis of the right kidney and similar but not so advanced changes in the pelvis and upper calyx of the left kidney. (Simril and Rose, *J. Urol.*, 1950, *63*, 588.) (*C*) Abscess of the lower pole of the left kidney with perinephritic abscess. Note the compression and elongation of the lower and middle calyces. (Confirmed by operation.)

secondary lesions may be classified, *viz.*, (a) perirenal, (b) multiple nodular metastases throughout the entire parenchyma, (c) diffuse interstitial infiltration, and (d) large solitary metastases. Pyelographic defects may occur in all types (Fig. 10, *E* and *F*). The first two types may cause bizarre defects in the outline of the calyces. The solitary metastatic type may produce the characteristic pyelographic defects and changes in the terminal calyces and pelvis associated with other renal neoplasms.

8. *Endometriosis.* This rare lesion occurs in women between the ages of twenty-two and forty-two years. The renal condition is practically always accompanied by pelvic endometriosis. Intravenous urography may reveal either blurring of the pelvis and calyces, or impaired excretion, or a completely excluded kidney. Retrograde pyelography is the most important diagnostic aid and may show a gross pyelocalyceal defect, cystic dilatation of a terminal calyx, or renal atrophy.

9. *Actinomycosis.* In 1951, Whisenand and Moore collected 16 cases of this rare disease. The renal lesion is usually the result of direct extension from other sources. The

kidney tissue reacts with the formation of nodules of chronic granulation tissue with subsequent replacement by connective tissue and fistula formation. The pyelographic findings vary according to the severity of the disease process, *viz.*, typical deformity of a renal tumor, motheaten appearance of tuberculosis, chronic infection of one or more calyces, or a perirenal abscess. The ureter may reveal changes simulating tuberculosis.

10. *Perirenal Hematoma or Abscess.* A collection of blood (Fig. 15*A*) or pus (Fig. 15*C*) in the perinephric tissue may cause a displacement of the kidney and ureter with resulting pyelographic changes in the pelvis and calyces which may be difficult to distinguish from intrarenal disease. Perinephritic abscess not infrequently is accompanied by an abscess or carbuncle in the kidney parenchyma (Fig. 15*C*) which may produce an intrinsic deformity in the pyelographic outline of one or more major and minor calyces.

SUMMARY

1. The diagnosis of the cause of hematuria of renal origin presents one of the most difficult problems in urology and radiology.

2. Urographic studies reveal that a wide variety of lesions of the renal papillae and calyces may be the causative factor.

3. These lesions have been classified and briefly discussed from a pathologic standpoint.

4. The outstanding urographic changes produced by these lesions have been described and pyelograms of the more commonly encountered lesions presented.

5. Such knowledge will eliminate most or all the diagnostic uncertainties of the group of obscure cases of renal hematuria which were erroneously diagnosed in the past as "essential" or "idiopathic" hematuria.

Julian O. Salik, M.D.
Sinai Hospital of Baltimore, Inc.
1714 East Monument Street
Baltimore 5, Maryland

A CLASSIFICATION OF THE UROGRAPHIC PATTERNS IN CHILDREN WITH CONGENITAL BLADDER NECK OBSTRUCTION*

By AURELIO C. USON, M.D., DONALD W. JOHNSON, M.D., JOHN K. LATTIMER, M.D., *and* MEYER M. MELICOW, M.D.
NEW YORK, NEW YORK

CHILDREN with congenital bladder neck obstruction, when first seen usually appear healthy and well nourished despite the fact that their urinary tracts may be seriously affected (Fig. 1). If the underlying pathologic condition is not recognized and/or properly treated, the changes in the upper urinary tracts become progressively worse, irreversible, and in due time incompatible with life. On the other hand, if early diagnosis and adequate management are instituted, the lives of the patients may not only be saved, but, in addition, a satisfactory anatomic and physiologic recovery of their urinary tracts may be obtained.

The roentgenographic findings and pathologic changes in the urinary tracts of children with congenital bladder neck obstruction are varied and often confusing. Furthermore, it has been noted, that when these children undergo routine urographic examination, without a rational approach to the problem, numerous roentgenograms are taken resulting in unnecessary exposure of the child to irradiation. For this reason, it was felt that a comprehensive urographic classification would be an aid in the initial evaluation of these patients, a guide to proper therapy and an important criterion in determining the effectiveness of treatment. To derive such classification the available roentgenograms (cystograms, intravenous urograms and retrograde pyelograms) of 158 children, 100 boys and 58 girls, with congenital bladder neck obstruction, were reviewed. The age of these patients ranged from one day to fourteen years. They were seen from January, 1938 to December, 1957 at the Pediatric Urological Service of the Squier Clinic and Babies Hospital of the Columbia-Presbyterian Medical Center. In 25 of these children cystograms were not done and therefore they have been excluded from the present report. From the study of the roentgenographic material of the remaining 133 cases, we formulated a working urographic classification of the changes in the urinary tract caused by the congenital obstruction at the bladder neck.

The cases were separated into two main groups based upon the *presence or absence of vesico-ureteral reflux* as demonstrated by cystography. Each group was further subdivided in three types according to the *status of the upper urinary tracts.*

GROUP I (44 CASES)

In this group no vesico-ureteral reflux is demonstrated by cystography.

Type A (13 cases). The *upper urinary tracts are normal* as revealed by intravenous and retrograde pyelography. Cystography, however, reveals large ovoid bladders, usually smooth in contour, but occasionally thick-walled with slight trabeculation and sacculation. Postvoiding cystograms show variable amounts of residual urine in the bladder (Fig. 2).

Type B (8 cases). There is *unilateral hydroureteronephrosis* of variable degree with evidence of trapping of urine in the dilated ureter, caused by obstruction at the ureterovesical junction. In some cases a small juxtameatal vesical diverticulum is noted on the side of the hydroureteronephrosis. The appearance of the bladder is similar to that seen in Type A (Fig. 3).

* From the Squier Urological Clinic, The Babies Hospital and The Columbia University College of Physicians and Surgeons, New York, New York.
A paper on the same subject was read by the senior author at the Meeting of the Genito Urinary Section of the New York Academy of Medicine and received the second prize of the Annual Essay Contest.

Fig. 1. H.W., B.H. No. 563879. Male, aged nine years, with a five year history of recurrent bouts of low grade fever and albuminuria. Enuresis for past two years. (*A*) Note his healthy and well nourished appearance despite the severe destruction of the urinary tract shown by the cystogram. (*B*) Note large bladder and ureteral reflux to pelves outlining enormously dilated and tortuous ureters, with bilateral hydronephrosis.

Type C (23 cases). There is *bilateral hydroureteronephrosis*, usually with impairment of renal function and obstruction at the ureterovesical junctions. Retrograde pyelography demonstrates the dilated tortuous ureters better than intravenous urography. "Trapping" within the ureters is well demonstrated on roentgenograms obtained after catheter drainage of the bladder. Occasionally, a tiny juxtameatal vesical diverticulum on each side is found. The changes in the bladder wall (thickening, trabeculation, etc.) are generally more severe than those seen in Types A and B (Fig. 4).

GROUP II (89 CASES)

In this group vesico-ureteral reflux is revealed by cystography.

Type A (11 cases). There is *unilateral vesico-ureteral reflux with variable degrees of hydroureteronephrosis*. In congenital bladder neck obstruction no instance of vesico-ureteral reflux was encountered without some degree of dilatation of the involved upper urinary tract. The dilated ureter may be quite elongated and tortuous. The appearance of the bladder, in general, is similar to that seen in Types A and B of Group I. Postvoiding cystograms show variable amounts of residual urine in the

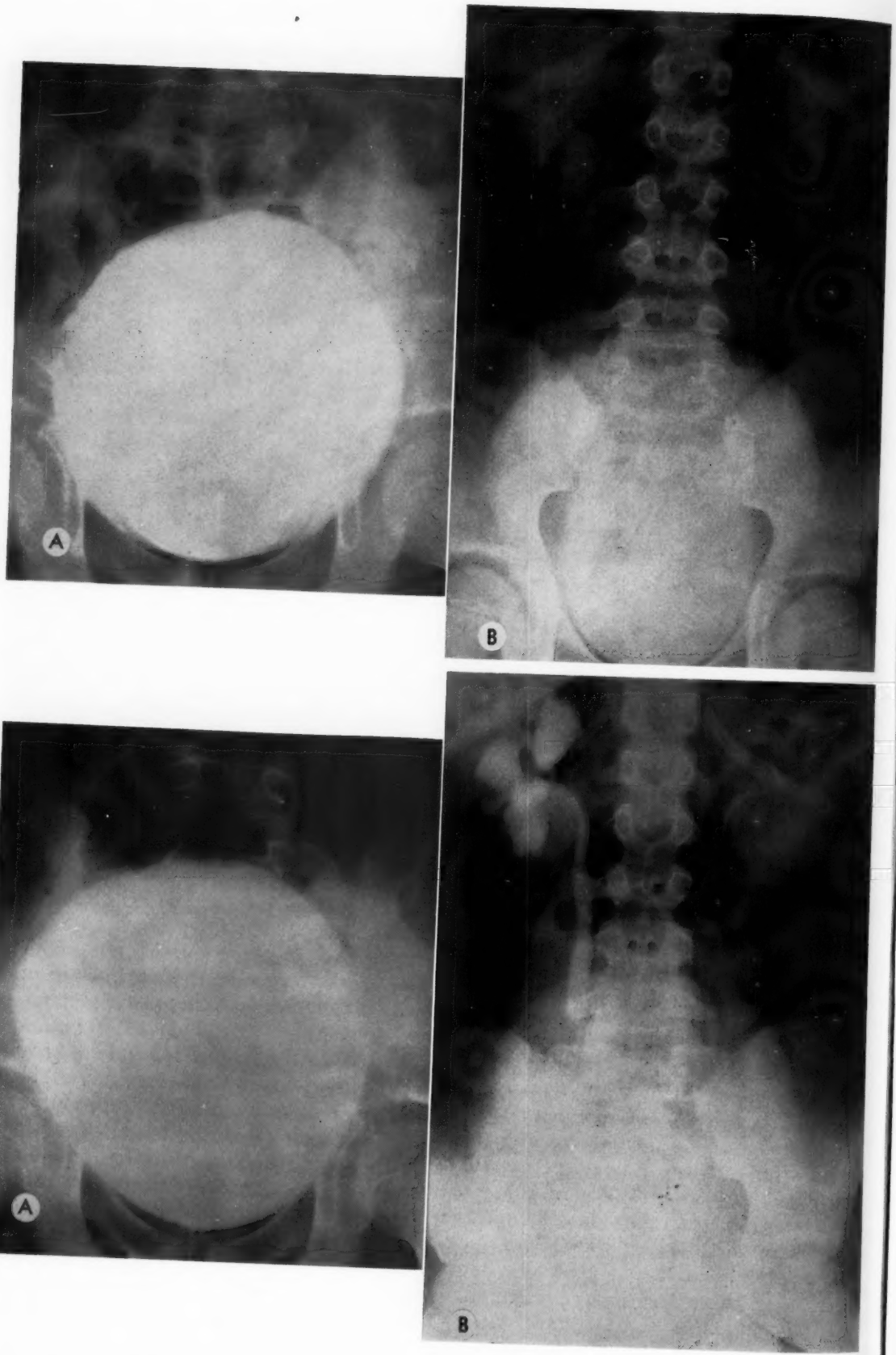

A
B
A
B

Fig. 2. Group I, Type A. *Dilated bladder but with no renal damage as yet.* A.G., B.H. No. 891574. Male, aged nine years. The patient was symptomless and a urologic investigation was performed because his older brother was found to have a congenital bladder neck obstruction (see Figure 3, Group I, Type B). (*A*) Cystogram shows large smooth bladder shadow without reflux even at the end of thirty minutes. (*B*) Abdominal roentgenogram taken seventy-five minutes after intravenous injection of contrast medium reveals normal upper urinary tract and large distended bladder.

bladder and in the dilated ureter. However, an organic obstruction at the ureterovesical junction is not always present. The redundancy of these ureters may interfere with adequate ureteral emptying. Excretory urography, with an indwelling catheter to allow adequate bladder drainage and to prevent vesico-ureteral reflux, may reveal impaired function of the involved kidney. The contralateral kidney and ureter are normal (Fig. 5).

Type B (20 cases). There is *dilatation of both upper urinary tracts*, with vesicoureteral reflux on one side and ureterovesical obstruction on the opposite side. Cystography reveals abnormalities similar to those seen in Group II, Type A. Retrograde and/or excretory pyelography, however, demonstrate hydroureteronephrosis also on the side where vesico-ureteral reflux does not occur due to stricture of the ureteral meatus. Excretory urography shows bilateral impairment of renal function in many instances. A small juxtameatal vesical diverticulum is occasionally noted on the side without reflux (Fig. 6).

Type C (58 cases). This is the largest single category and is characterized by *bilateral vesico-ureteral reflux with bilateral hydroureteronephrosis*. The degree of involvement of the upper urinary tracts tends to be more marked than in the previous types and is often symmetric in individual patients. Postvoiding cystograms show residual urine in the bladder because of the bladder neck obstruction, and also in the upper tracts because of ureteral redundancy, atony and at times strictures at the ureterovesical junctions. In the latter the ureteral meati are not only incompetent (allowing reflux) but also stenosed. Excretory urography reveals diminished renal function with nonvisualization in advanced cases. The trabeculation and sacculation of the bladder are often more marked than those seen in any of the preceding types in both groups, but the bladder is usually smaller (Fig. 7). In rare instances a fusiform dilatation of the posterior urethra, suggesting the presence of urethral valves, may be present (Fig. 8 and 9).

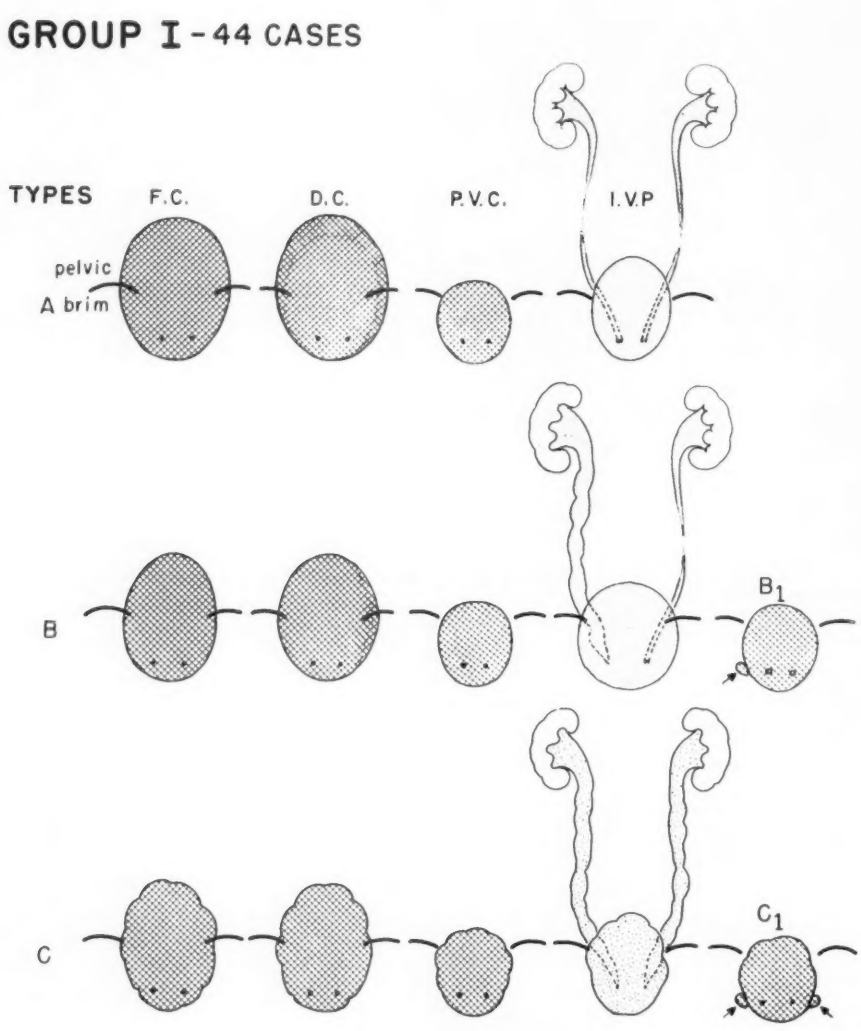
Table 1 gives the cystographic findings in 133 children with congenital bladder neck obstruction. These are separately diagrammed for Group I and Group II, by illustrating the Type A, B, C lesions in each group. (See Diagrams of Group I and Diagrams of Group II.)

Table I

CYSTOGRAPHIC FINDINGS IN 133 CHILDREN WITH CONGENITAL BLADDER NECK OBSTRUCTION

Group I. Large bladder but no reflux	44 Cases
Group II. Large bladder and reflux of one or both ureters	89 Cases

Fig. 3. Group I, Type B. *Dilated bladder without reflux but with unilateral hydroureteronephrosis.* S.G., B.H. No. 906717. Male, aged ten years, brother of patient whose urographic studies are described in Figure 2. There was a history of intermittent urinary difficulty, fever and right flank pain for six years. (*A*) Delayed cystogram shows a large smooth bladder shadow without reflux. (*B*) Abdominal roentgenogram taken seventy-five minutes after intravenous injection of contrast medium reveals hydroureteronephrosis on the right side and a normal tract on the left side. The distended urinary bladder is again visualized.



Diagrams of Group I

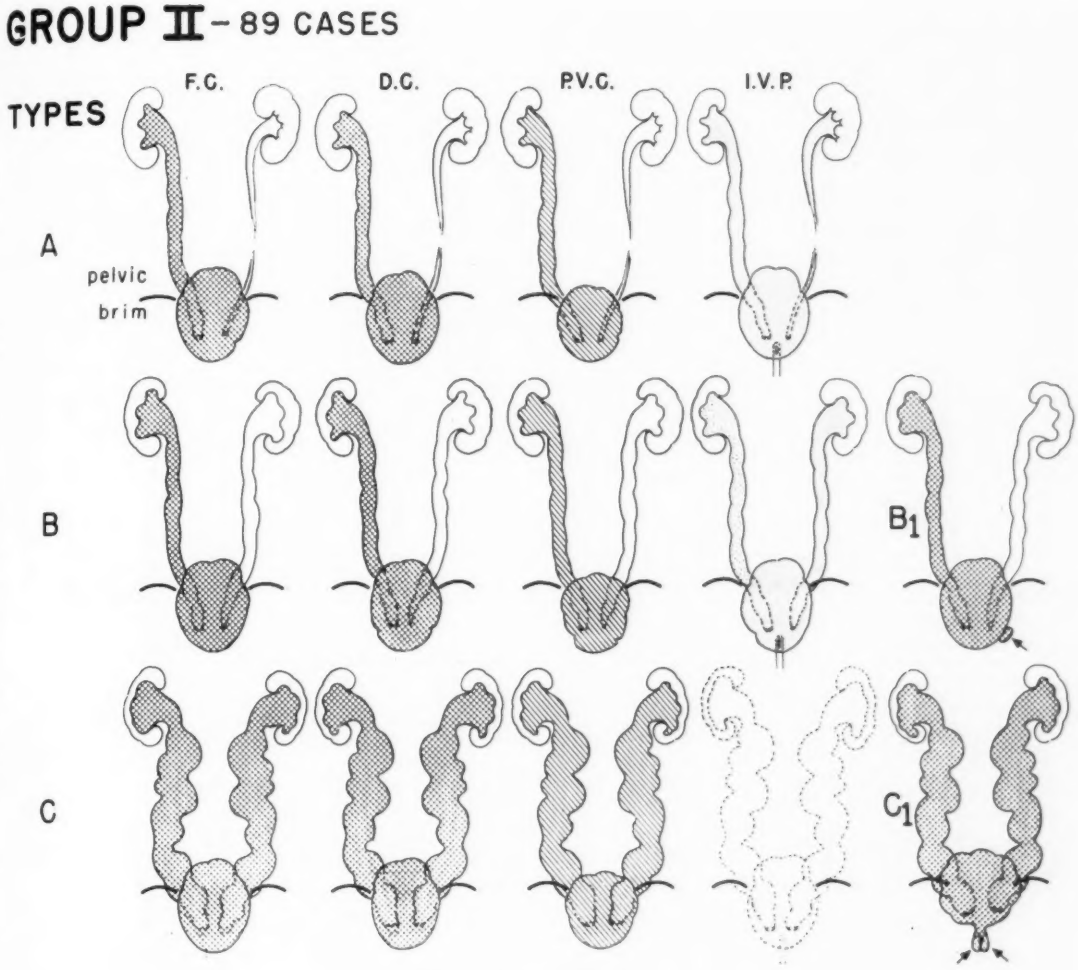
PATIENTS WITH LARGE BLADDER BUT NO REFLUX—44 CASES

Type A. With normal upper urinary tract	13 Cases
Type B. With unilateral hydronephrosis	8 Cases
Type C. With bilateral hydronephrosis	23 Cases

F.C. Filling cystogram. D.C. Delayed cystogram. P.V.C. Postvoiding cystogram.
I.V.P. Intravenous pyelogram.

DISCUSSION

During the clinical evaluation of children suspected of having congenital bladder neck obstruction, plain roentgenography of the abdomen, cystography and intravenous urography are usually performed. Retrograde pyelography and urethrography are employed less frequently. At present cystography with "floating lipiodol" is also included, as originally suggested by Young *et al.*[9] An evaluation of this technique will be reported in the near future by Roberts.[5] Considerable useful information is obtained from cystographic studies, as recommended by Stewart[6,7] and Williams[8] or according to the standardized



Diagrams of Group II

PATIENTS WITH LARGE BLADDER AND REFLUX OF ONE OR BOTH URETERS—89 CASES

Type A. With unilateral reflux and unilateral hydronephrosis	11 Cases
Type B. With unilateral reflux and bilateral hydronephrosis	20 Cases
Type C. With bilateral reflux and bilateral hydronephrosis	58 Cases

F.C. Filling cystogram. D.C. Delayed cystogram. P.V.C. Postvoiding cystogram.
I.V.P. Intravenous pyelogram.

technique reported by Dean, Lattimer and McCoy.[2] A thirty minute delayed and several postvoiding roentgenograms are always taken so that the vesico-ureteral reflux, vesical residual of urine and upper tract drainage are at once determined.[4] The time interval between voidings, as well as the amounts of each voiding, are recorded. In children who cannot follow this routine, the bladder is emptied via the urethral catheter and successive roentgenograms of the abdomen are taken whenever vesico-ureteral reflux is present. Voiding cystourethrograms, as recently recommended and beautifully demonstrated in a book by Kjellberg *et al.*,[3] may disclose important pathologic lesions, particularly at the posterior urethra. An antibiotic—neo-

Fig. 4. Group I, Type C. *Dilated bladder with no reflux but bilateral hydroureteronephrosis.* R.H., B.H. No. 948738. Male, aged five years, with a six month history of progressive urinary difficulty culminating in acute urinary retention, accompanied by fever and a serum nonprotein nitrogen value of 81 mg./100 cc. of blood. (*A*) A thirty minute delayed filling cystogram reveals an elongated bladder shadow with numerous sacculations. (*B*) Abdominal roentgenogram taken two hours after intravenous injection of the contrast medium, shows poor renal excretion of the contrast medium. (*C*) Abdominal roentgenogram taken fifty minutes after retrograde filling of both ureters with contrast medium demonstrates pronounced hydroureteronephrosis, particularly on the right side in which a better filling of the ureter and pelvis was

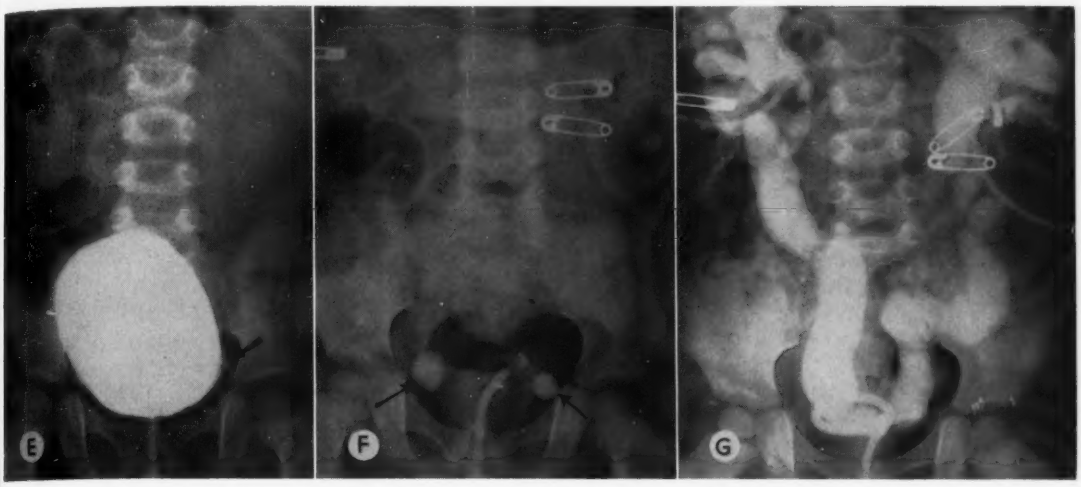


Fig. 4. (*E*) G.N., B.H. No. 267640. Filling cystogram. Note juxtameatal diverticulum on left side. The presence of a similar diverticulum on the right was obscured by the density of the opaque medium within the distended bladder. (*F*) Same as *E*. Note bilateral juxtameatal diverticula which are now clearly shown because the bladder had been emptied of the contrast medium. (*G*) A thirty minute delayed bilateral pyelogram through the nephrostomy tubes shows advanced hydroureteronephrosis and obstruction in both ureterovesical junctions.

Fig. 5. Group II, Type A. *Large bladder with unilateral reflux and hydroureteronephrosis on the side of reflux The contralateral upper urinary tract is normal.* R.B., B.H. No. 691170. Male, aged three years, with "unexplained" fever of 105° F. for two weeks. (*A*) Filling cystogram reveals large smooth bladder shadow and free left ureteropelvic reflux outlining a dilated tortuous ureter and a hydronephrosis. There is no reflux on the right side. (*B*) Abdominal roentgenogram taken two hours after the intravenous injection of contrast medium shows left hydronephrosis. The right kidney excreted most of the contrast medium promptly, though some of it is still present in an otherwise normal pelvis and ureter. (*C*) Bilateral retrograde pyelogram shows a relatively normal right upper urinary tract and a hydroureteronephrosis on the left side. The reproductions in *A*, *B* and *C* are LogEgrams.

obtained. Note the "pencil-shaped" ureters due to stricture at the ureterovesical junction. (*D*) Abdominal roentgenogram taken ninety minutes after *C* shows as in *C* bilateral ureteropelvic trapping of the injected substance.

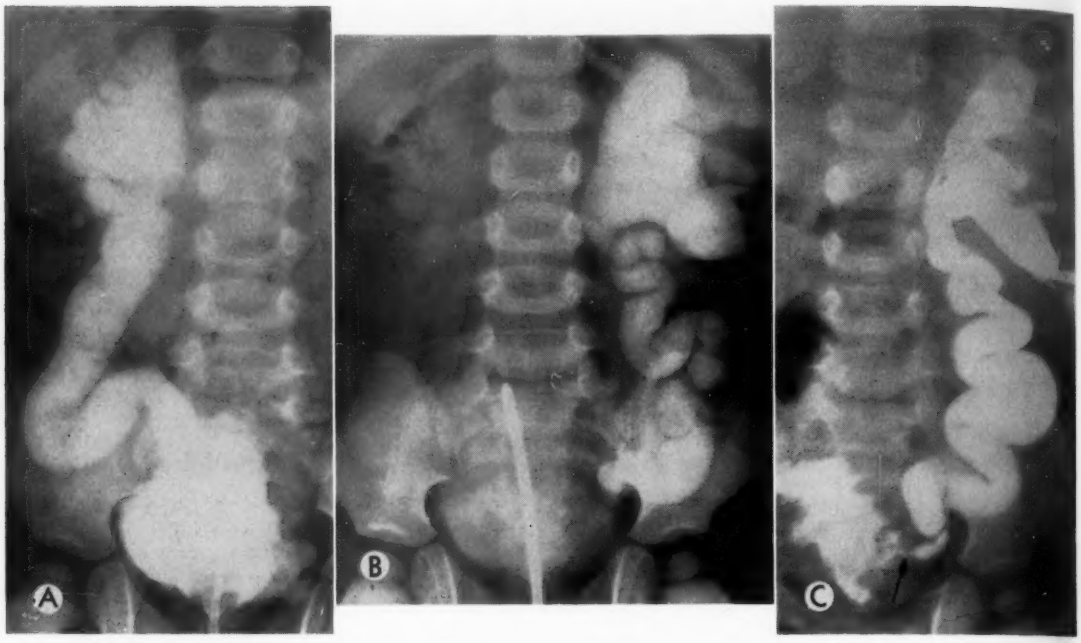


Fig. 6. Group II, Type B. *The bladder is usually smaller than in the previous types, with unilateral reflux and bilateral hydroureteronephrosis.* J.O., B.H. No. 142484. Male, aged one and one-half years with an eight month history of recurrent bouts of fever up to 103° F., vomiting and episodes of crying. (*A*) Filling cystogram reveals free reflux on the right side outlining a right hydroureteronephrosis. There was no reflux on the left side. (*B*) Abdominal roentgenogram taken seventy-five minutes after intravenous injection of contrast medium shows tortuous left ureter and left hydroureteronephrosis, and almost functionless right kidney. (*C*) A thirty minute delayed pyelogram through left nephrostomy tube demonstrates the site of obstruction at the ureterovesical junction with evidence of trapping of the contrast medium in the left ureter and pelvis.

bycin or tetracycline—is usually mixed with the contrast medium at the time of cystography, particularly if reflux is anticipated. Cystography is always carried out under meticulous asepsis and usually without anesthesia.

Admittedly cystography has several disadvantages: (1) the test requires a urethral catheterization with the subsequent danger of trauma and infection; (2) the catheterization may alter or distort the urethral or bladder neck obstructive lesions; and (3) there is a hazard of precipitating an ascending infection in either kidney, particularly if reflux and retention are present.

Intravenous urography is performed before or after the cystography and only if the nonprotein nitrogen is not elevated and the child's general condition and sensitivity to the contrast medium have been evaluated. The roentgenograms are usually taken at ten, forty, and seventy-five minute intervals. Delayed roentgenograms from one to several hours are often necessary when renal function is impaired.

In those cases in which intravenous urography is performed before cystography, postvoiding roentgenograms may be obtained at the end of seventy-five minutes or later. If intravenous urography is done after cystography has revealed reflux or if it is performed in patients requiring an indwelling urethral catheter, the catheter should be left unclamped. Retrograde pyelography is not indicated when vesicoureteral reflux is present because the latter usually outlines adequately the upper urinary tracts. On the other hand, if there is no reflux and the status of the upper urinary tracts needs clarification because of poor or nonvisualization by intravenous urography, retrograde pyelography is usu-

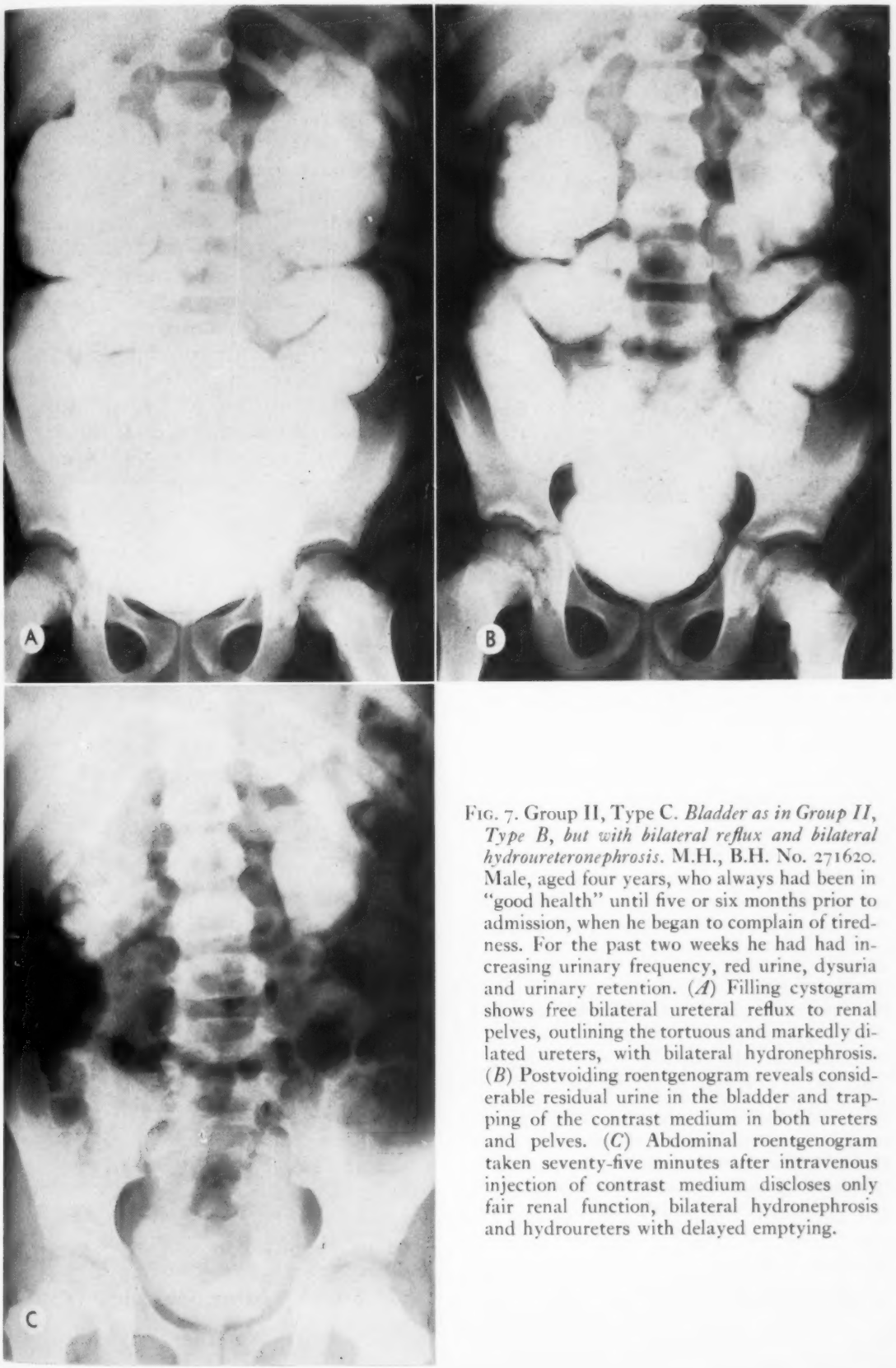


Fig. 7. Group II, Type C. *Bladder as in Group II, Type B, but with bilateral reflux and bilateral hydroureteronephrosis.* M.H., B.H. No. 271620. Male, aged four years, who always had been in "good health" until five or six months prior to admission, when he began to complain of tiredness. For the past two weeks he had had increasing urinary frequency, red urine, dysuria and urinary retention. (*A*) Filling cystogram shows free bilateral ureteral reflux to renal pelves, outlining the tortuous and markedly dilated ureters, with bilateral hydronephrosis. (*B*) Postvoiding roentgenogram reveals considerable residual urine in the bladder and trapping of the contrast medium in both ureters and pelves. (*C*) Abdominal roentgenogram taken seventy-five minutes after intravenous injection of contrast medium discloses only fair renal function, bilateral hydronephrosis and hydroureters with delayed emptying.

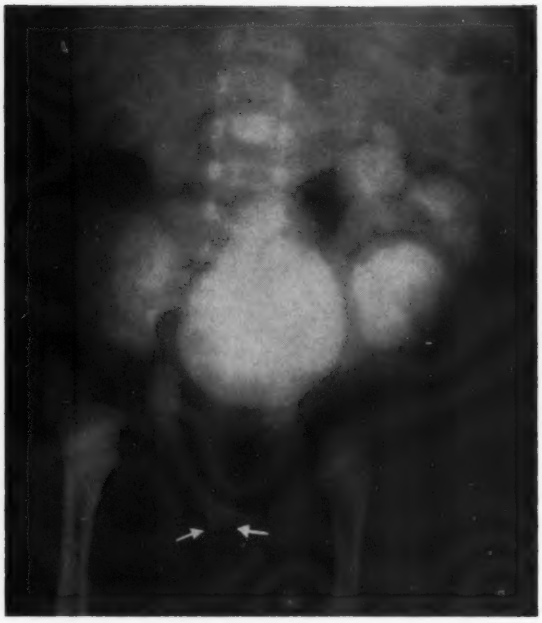


Fig. 8. Group II, Type C. *Bilateral vesico-ureteral reflux with bilateral hydroureteronephrosis.* A.Ch., B.H. No. 064196. Male, aged seven days, born with a weakness of the abdominal wall musculature and other anomalies. Filling cystogram reveals a pear-shaped bladder with free bilateral ureteral reflux to renal pelves, outlining both ureters, which appear to be dilated and tortuous. A fusiform dilatation of the posterior urethra was also present, but overlooked. At autopsy two *posterior urethral valves* were found.

ally performed after endoscopic examination of the bladder. In children this procedure requires general anesthesia.

Retrograde urethrography has seldom been performed in our patients. However, this procedure may be indicated in specific cases, *i.e.* urethral diverticulum, urethrorectal fistulae, or severe urethral strictures, which may not allow catheterization. In the latter instance or whenever the presence of posterior urethral valves is suspected, it is safer to avoid any urethral instrumentation because such manipulations may precipitate a severe urinary and generalized infection which can cause the patient's death. In such cases an emergency suprapubic cystostomy or bilateral nephrostomy as a life saving procedure may be necessary. Posterior urethral valves, in our experience, are uncommon and represent a rather severe obstructive lesion with a grave outlook. They were found in 12 out of 158 cases with congenital bladder neck obstruction. The ages in these children, with complete posterior urethral valves, ranged from one day to ten months, the majority being in the first two months of life. Most of them were severely ill on admission and died shortly thereafter. Usually the precipitating factors were cystography, urethral catheterization or simple meatotomy. Hyperpyrexia of 104° to 105° F., vomiting, uremia, electrolyte imbalance and other disturbances were noted a few days prior to death. Except in 2 instances, the valves were not recognized or visualized during the clinical evaluation. In retrospect, however, some of the urethral valves could have been diagnosed from the original cystographic or urographic studies. In 4 of the 12 children with urethral valves, congenital deficiency of the abdominal musculature was also present.

As already stated, it is important to avoid urethral instrumentation in children suspected of having urethral valves. Sometimes, it may be advantageous to employ a procedure which in the past has been used in adults. A suprapubic needle puncture of the bladder is performed and part of its contents aspirated. A few cubic centimeters of contrast medium are then injected and the needle withdrawn. Immediate and postvoiding roentgenograms are obtained. Important information as to the pathologic nature of the obstruction at the bladder neck, the presence of vesico-ureteral reflux and the status of the upper urinary tracts may thereby be secured. This procedure, however, has not as yet been employed in our cases.

The cause, development and significance of the juxtameatal diverticula which were encountered in some of these patients with congenital bladder neck obstruction are not fully understood. We believe that these diverticula are of congenital origin and that their development takes place as follows: The resistance of emptying caused by bladder neck obstruction must be over-

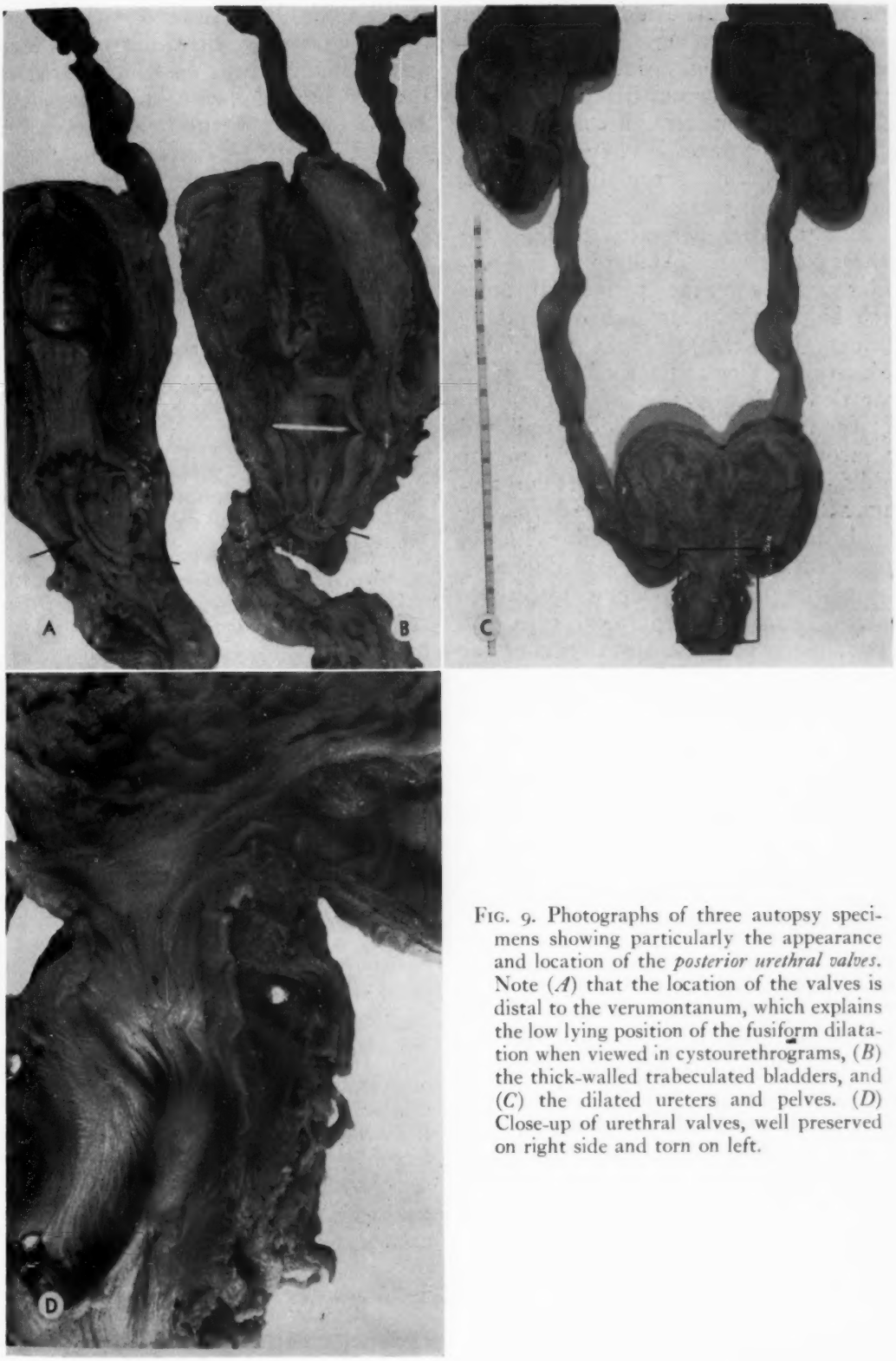


Fig. 9. Photographs of three autopsy specimens showing particularly the appearance and location of the *posterior urethral valves*. Note (*A*) that the location of the valves is distal to the verumontanum, which explains the low lying position of the fusiform dilatation when viewed in cystourethrograms, (*B*) the thick-walled trabeculated bladders, and (*C*) the dilated ureters and pelves. (*D*) Close-up of urethral valves, well preserved on right side and torn on left.

come as otherwise the bladder will continue to dilate in order to accommodate the increasing amounts of residual urine. The detrusor, by its vigorous attempts to empty the bladder completely, becomes hypertrophied. This process is uneven and as a result trabeculation, sacculation and outpouching of diverticula of the mucosa occur. The latter herniates through the weakest points in the bladder wall and particularly through the perimeatal areas which in some patients are congenitally deficient (Chwalle[1]). These potentially weak areas develop at the time of splaying, separation and migration of the wolffian duct from the posterior bladder wall and the incorporation of the ureter into the bladder. It is conceivable that the continuous increase in residual urine during the second half of the intrauterine life in fetuses with obstruction at the bladder neck may precipitate the development of juxtameatal diverticula. The latter in turn, due to their position, cause obstruction of the intramural portion of the ureters. Thus, this diverticulum has clinical significance.

SUMMARY

1. The roentgenographic findings in 133 children with congenital bladder neck obstruction have been presented and a classification has been proposed based on (I) the presence or absence of vesicoureteral reflux and (II) the status of the upper urinary tracts.

2. The rationale in the urographic workup during the clinical evaluation of patients with suspected congenital bladder neck obstruction has been discussed. A theory as to the genesis of the juxtameatal vesical diverticula has been presented.

3. The value of the classification which has been presented is, in our opinion, threefold: (a) It can be used as a guide in the initial evaluation of children with congenital bladder neck obstruction, reducing thereby the number of roentgenographic exposures, and in grouping properly the varied urographic patterns that are seen in these patients; (b) it can be employed as an aid in selecting the particular therapy best suited for any given case of congenital bladder neck obstruction; and (c) it can be utilized as an objective criterion in evaluating accurately the results obtained from the various types of treatment.

Aurelio C. Uson, M.D.
Columbia University College of Physicians and Surgeons
620 West 168th Street
New York 32, New York

REFERENCES

1. Chwalle, R. Progress of formation of cystic dilatations of vesical end of ureter and of diverticula at ureteral ostium. *Urol. & Cutan. Rev.*, 1927, *31*, 499–504.
2. Dean, A. L., Jr., Lattimer, J. K., and McCoy, C. B. Standardized Columbia University cystogram. *J. Urol.*, 1957, *78*, 662–668.
3. Kjellberg, S. R., Ericsson, N. O., and Rudhe, U. The Lower Urinary Tract in Childhood: Some Correlated Clinical and Roentgenologic Observations. Year Book Publishers, Inc., Chicago, 1957, pp. 172–266.
4. Lattimer, J. K., Dean, A. L., Jr., and Furey, C. A. Triple voiding technique in children with dilated urinary tracts. *J. Urol.*, 1956, *76*, 656–660.
5. Roberts, M. S. Personal communication.
6. Stewart, C. M. Delayed cystograms. *J. Urol.*, 1953, *70*, 588–593.
7. Stewart, C. M. Delayed cystography and voiding cystoureterography. *J. Urol.*, 1955, *74*, 749–759.
8. Williams, D. I. Radiological diagnosis of lower urinary obstruction in early years. *Brit. J. Radiol.*, 1954, *27*, 473–481.
9. Young, B. W., Anderson, W. L., and King, G. G. Radiographic estimation of residual urine in children. *J. Urol.*, 1956, *75*, 263–272.

Vol. 80, No. 4

THE ROENTGEN MANIFESTATIONS OF CARCINOMA AND CYST IN THE SAME KIDNEY*

REPORT OF A CASE

By DANIEL J. PISANO, M.D.,† ROBERT HOWARD ROSEN, M.D.,‡ BERTA M. RUBINSTEIN, M.D.,§ *and* HAROLD G. JACOBSON, M.D.‖

NEW YORK, NEW YORK

THE usual urologic work-up of a patient for a suspected mass in the kidney includes the time-tested methods of history and physical examination; various laboratory studies, such as urinalysis and complete blood cell count; plain roentgenography of the abdomen; roentgenography of the chest and skeleton for possible metastases; intravenous and retrograde pyelography and cystoscopy. Recently, aortography and nephrotomography have started to play a role in the diagnosis of space-occupying masses in the kidney. Although intravenous and retrograde pyelography are of obvious importance, we have found that nephrotomography using, in the main, the technique advocated by Evans and coworkers[6,7] is a procedure which has proved to be a valuable adjunct in both the diagnosis and the differential diagnosis of space-occupying masses in the kidney.

Briefly, nephrotomography is carried out by the rapid injection of one of the various opacifying media used today in intravenous urography. The medium of choice in this institution is renografin (Squibb), because of its relative safety and index of excellent opacification.[11,23] After preliminary laminagraphic cuts of the abdomen are made to delineate the most accurate level for kidney visualization, 50 cc. of renografin is injected as rapidly as possible into the antecubital vein. Decholin circulation time studies are done prior to the injection of renografin and 5 cc. of decholin is mixed with the intravenously administered renografin. Depending on the circulation time obtained from the decholin studies, tomographic exposures at the level indicated in the preliminary films are made at the time considered optimal for opacification of the kidneys. Recently, we have attempted to pinpoint this time sequence more accurately by using radioactive iodinated human serum albumin with renografin. A Geiger-Müller counter is used over the abdominal aorta in the region of the renal arteries to indicate the exact time of entry of the radioactive tagged opaque medium into the abdominal aorta.

True cysts in the kidney are generally manifested in nephrotomography by a well circumscribed outline with a radiolucent center, while malignant neoplasms of the kidney show an increase in density of the renal parenchyma in the tumor region, or a fine arborization of vessels to the tumor area. Evans and his associates[6,7] have demonstrated adequately the accuracy of nephrotomography in differentiating cyst from tumor.

In this presentation, we will illustrate a case in which a nephrotomographic examination showed the presence of both a solid transitional cell carcinoma of the renal pelvis, as well as an unrelated cyst of the same kidney, both clearly visible in the roentgenograms. Actually, the true nature of the two lesions was not appreciated by either the Radiology Department or the Urologic Section until the surgical procedure was carried out, but the diagnosis of two unrelated lesions could have been made with a more careful evaluation of the roentgenograms.

The literature reveals a number of cases

* From the Division of Diagnostic Radiology and Section of Urology, Division of Surgery, Montefiore Hospital.
† Chief Resident, Division of Diagnostic Radiology, Montefiore Hospital.
‡ Formerly Resident, Division of Surgery, Montefiore Hospital.
§ Adjunct Attending Radiologist, Montefiore Hospital.
‖ Chief, Division of Diagnostic Radiology, Montefiore Hospital and Clinical Professor of Radiology, New York University College of Medicine.

of two unrelated lesions of the same kidney, as well as associated double lesions. Cunningham,[4] in 1916, reported a case of a solitary cyst and an unrelated carcinoma of the same kidney. In 1928, Colston[3] also reported a solitary cyst and a papillary cyst-adenocarcinoma occurring simultaneously in one kidney. Neff,[14] in 1932, described a case of Wilms' tumor in a pre-existing cyst. Ezickson and Greene,[8] in 1937, published a case of adenocarcinoma developing in the wall of a single cyst. Prather,[16] in 1950, discussed the problems in the differential diagnosis between tumor and cyst. He concluded that surgical exploration was necessary in any space-occupying lesion of the kidney. He showed a pathologic specimen of a double lesion: a cyst of the upper pole and a carcinoma involving the middle and lower portions of the same kidney.

Triska,[21] in 1951, recorded a case with a benign papilloma of the superior renal calyx with an unassociated cyst of the same kidney. Lewis and Kimbrough,[12] in 1952, described a case of bilateral hypernephroma, associated with polycystic disease. In 1953, Pagel[15] presented a case of renal pelvic papilloma with an unrelated cyst of the same kidney. His review of the world literature at that time revealed only one such previously reported case, that by Triska in 1951. Johnson,[10] in 1953, published a case of carcinoma in a polycystic kidney. Sease,[20] in 1953, reported a case of a multiloculated cyst of the kidney with malignant changes. Borski and Kimbrough,[2] in 1954, demonstrated a case of bilateral carcinoma in polycystic renal disease. Emanuel,[5] in 1954, presented 2 cases of clear cell carcinoma occurring in a solitary cyst wall. In 1954, Gibson[9] reported 3 cases of double lesions of the same kidney. He described a cyst with a sarcoma, a cyst with a clear cell carcinoma and a cyst with a granular cell tumor of the kidney.

Schweibinger and Hodges,[19] in 1955, reviewed the literature and added 2 cases of unrelated double kidney lesions. One of their cases was a large cyst with an unassociated papillary transitional cell carcinoma arising from the superior calyx. The second case was that of a cyst of the lower pole with an unassociated adenocarcinoma of the upper pole of the same kidney. Provet, Lisa and Trinidad,[17] in 1956, reported a case of tubular carcinoma within a solitary cyst. Marchetto and Zeitel,[13] in 1956, described 2 cases of carcinoma and polycystic disease in horseshoe kidneys. Ritter and Johnson,[18] in 1956, maintained that the differential diagnosis between cyst and tumor was subject to a very high percentage of error and advocated surgical exploration of all masses of the kidney. Their conclusions were based on their own findings and reported data[22] that about 2 per cent of all cases of solitary cysts of the kidney have associated tumor within the cyst walls. Additionally, 30 per cent of hemorrhagic cysts show carcinoma within them,[22] and 2 per cent of even clear fluid cysts are malignant. Although Ritter and Johnson mention the use of aortography and laminagraphy in their diagnostic procedures, they did not use nephrotomography. They present 7 cases, one of which was that of a small cyst, 2.5 cm. in diameter, with an apparently unassociated hypernephroma of the same kidney.

A review of the literature has shown only one case (that reported by Schweibinger and Hodges) with pathologic findings similar to ours. The following is the second proved case report of a transitional cell carcinoma of the kidney with an unrelated cyst of the same kidney.

REPORT OF A CASE

This was the first admission of a seventy year old white male, who entered Montefiore Hospital with a history of gross hematuria, dysuria and frequency of twenty-four hours' duration. The past history included intermittent episodes of similar nature in the two years prior to admission. An abdominal roentgenogram taken at another hospital during his first such episode showed a questionable calculus in the left renal area. No further work-up was carried out after a spontaneous remission of symptoms.

Physical examination on admission was un-

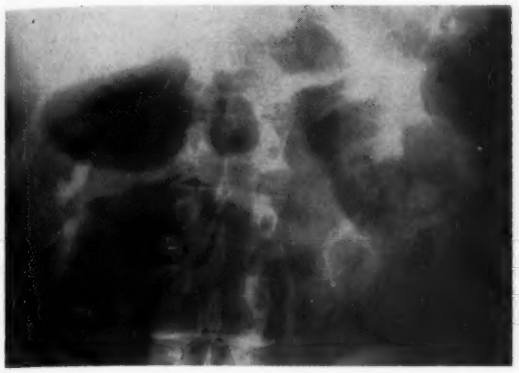


Fig. 1. Intravenous pyelogram showing normal right-sided collecting system with poor visualization of left upper urinary tract. A moderate pyelectasia is seen on the left.

remarkable except for some mild tenderness in the left costovertebral angle region. The prostate was not enlarged. Intravenous pyelography showed an enlarged left kidney with poor excretion of opaque medium on this side. There was a moderate pyelocaliectasia on the left

Fig. 2. Retrograde pyelogram showing irregular filling defect of the left renal pelvis representing the transitional cell carcinoma found at surgery.

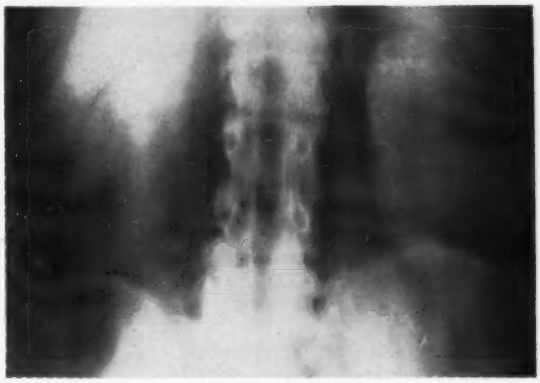


Fig. 3. Nephrotomogram showing the large spheroid radiolucency of the upper pole of the left kidney representing a large cyst. The neoplasm of the renal pelvis of the same kidney is not well delineated.

(Fig. 1). The left ureter was normal. The collecting system of the right upper urinary tract was normal.

Left retrograde pyelography demonstrated an irregular contour defect of the renal pelvis suggesting a malignant renal neoplasm (Fig. 2).

Nephrotomography done the following day showed a large, 8 cm. spheroid radiolucency in the upper portion of the left kidney "suggestive of a cyst" (Fig. 3 and 4).

At cystoscopy, a small papilloma of the bladder was found. It was felt that the bladder papilloma was a metastatic seeding from the probable carcinoma of the renal pelvis.

On February 20, 1957, through the usual kidney incision, the left kidney area was explored. The operating surgeon, after inspecting the left kidney, decided to further expose the kidney through a left lower quadrant "hockey-stick" incision. The surgeon then removed the

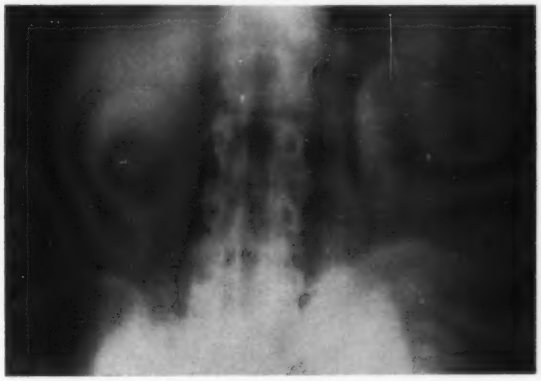


Fig. 4. Same as Figure 3.

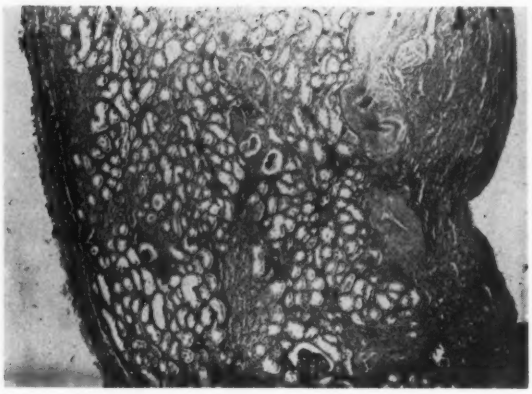


FIG. 5. Photomicrograph showing thinned out kidney parenchyma and cyst wall with no tumor (35×).

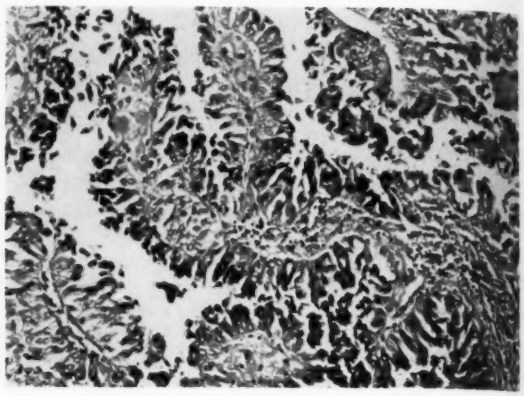


FIG. 6. Photomicrograph showing transitional cell carcinoma of left renal pelvis (95×).

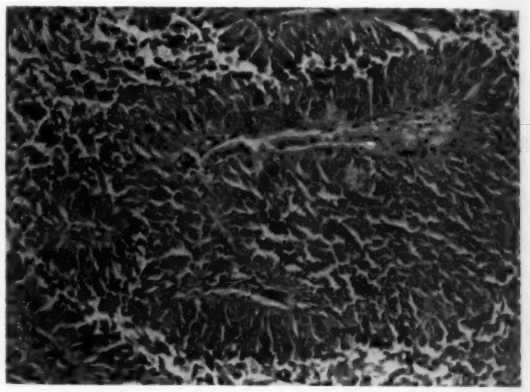


FIG. 7. Same as Figure 6. Different field (95×).

left kidney, ureter and a section of the bladder in continuity.

The gross specimen* showed a kidney measuring 12×7×5.5 cm. in size with mild pyelectasia. On the superior aspect there was a large cyst measuring approximately 7×6×5 cm. in size, with a thin transparent wall surrounded by a pale grayish capsule. In the pelvis there was a soft cauliflower growth measuring 5×5×3 cm. in its greatest dimension. Part of the tumor appeared necrotic and reddish gray in appearance.

Microscopic sections demonstrated compressed renal tissue and compression of the renal capsule immediately adjacent to the cyst. Some areas around the cyst showed no evidence of renal parenchyma except for a thin shell of fibrous connective tissue. The cyst wall was well demonstrated. There was no evidence of neoplasm in or associated with the cyst wall (Fig. 5). The tumor of the kidney pelvis showed marked atypism and moderate hyperchromatism with mitoses being present (Fig. 6 and 7). There was a broad base with some extension of the tumor into the muscular wall. The final impression was a papillary transitional cell carcinoma of the renal pelvis and a large unassociated renal cyst of the same kidney.

* We are indebted to the Pathology Department, Division of Laboratories, for the gross and microscopic descriptions of the specimens.

A three month follow-up showed the patient to be in good physical condition and asymptomatic. Follow-up cystoscopy and intravenous pyelography revealed normal findings.

DISCUSSION

In no instance in our experience has nephrotomography proved its value more strikingly than in the case we have just described. On intravenous and retrograde pyelography, a tumor in the left renal pelvis was demonstrated, but the presence of an additional space-occupying mass (a cyst) could not be recognized.

In the nephrotomographic examination, a solid mass in the region of the pelvis of the left kidney was adequately demarcated, and although the cyst was outlined, the true nature of the two separate lesions was

not clearly appreciated until after the surgical procedure. It is only with nephrotomography that the differential diagnosis of cyst and malignant tumor in a kidney is possible preoperatively. Also by this method, separate and distinct lesions in the same kidney may be diagnosed accurately. Such a diagnosis by intravenous and/or retrograde pyelography is, in our opinion, relatively unlikely. As experience with nephrotomography grows, we feel that this procedure will become more or less routine in busy teaching centers, where renal masses are commonplace.

SUMMARY AND CONCLUSIONS

We have presented a case of a large cyst of the upper pole of the left kidney with an unassociated, independent transitional cell carcinoma of the pelvis of the same kidney.

The importance of nephrotomography has been discussed and the technical aspects of this procedure briefly described. In our case, although the preoperative diagnosis was not fully appreciated roentgenographically from the nephrotomograms, the diagnosis could have been established. A review of the literature concerning double lesions of the kidney is given. A plea for the more frequent use of nephrotomography is made.

Harold G. Jacobson, M.D.
Montefiore Hospital
210th Street and Bainbridge Avenue
New York 67, New York

REFERENCES

1. Ainsworth, W. L., and Vest, S. A. Differential diagnosis between renal tumors and cysts. *J. Urol.*, 1951, *66*, 740–749.
2. Borski, A. A., and Kimbrough, J. C. Bilateral carcinoma in polycystic renal disease—unique case. *J. Urol.*, 1954, *71*, 677–681.
3. Colston, J. A. C. Solitary cyst and papillary cystadenoma occurring simultaneously in one kidney. *J. Urol.*, 1928, *19*, 285–290.
4. Cunningham, J. H., Jr. Large solitary and multiple cyst of kidney. *Surg., Gynec., & Obst.*, 1916, *23*, 688–696.
5. Emanuel, M. Surgical implications of solitary cyst associated with small renal neoplasm. *J. Maine M. A.*, 1954, *45*, 189–191.
6. Evans, J. A., Dubilier, W., Jr., and Monteith, J. C. Nephrotomography; preliminary report. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1954, *71*, 213–223.
7. Evans, J. A., Monteith, J. C., and Dubilier, W., Jr. Nephrotomography. *Radiology*, 1955, *64*, 655–663.
8. Ezickson, W. J., and Greene, L. B. Solitary cyst of kidney with adeno-carcinoma in walls of cyst. *J. Urol.*, 1937, *38*, 153–159.
9. Gibson, T. E. Interrelationship of renal cysts and tumors; report of 3 cases. *J. Urol.*, 1954, *71*, 241–252.
10. Johnson, W. F. Carcinoma in polycystic kidney. *J. Urol.*, 1953, *69*, 10–12.
11. Lentino, W., Zeitel, B. E., Jacobson, H. G., and Poppel, M. H. Intravenously given urographic mediums. *J.A.M.A.*, 1956, *161*, 606–609.
12. Lewis, E. L., and Kimbrough, J. C. Bilateral hypernephroma associated with polycystic disease. *Urol. & Cutan. Rev.*, 1952, *56*, 79–80.
13. Marchetto, I., and Zeitel, B. Two cases of horshoe kidneys with carcinoma and polycystic disease. *Minerva Urol.*, 1956, *8*, 73–75.
14. Neff, J. H. Massive hemorrhagic cyst in Wilms' tumor of kidney in adult. *J. Urol.*, 1932, *28*, 65–76.
15. Pagel, W. Solitärcyste und Nierenbeckentumor; ein kasuistischer Beitrag. *Ztschr. f. Urol.*, 1953, *46*, 546–550.
16. Prather, G. C. Differential diagnosis between renal tumor and renal cyst. *J. Urol.*, 1950, *64*, 193–199.
17. Provet, H., Lisa, J. R., and Trinidad, S. Tubular carcinoma of kidney within solitary cyst. *J. Urol.*, 1956, *75*, 627–632.
18. Ritter, J. S., and Johnson, A. A. Differential diagnosis and management of renal cysts associated with tumor. *New York J. Med.*, 1956, *56*, Pt. II, 2979–2984.
19. Schweibinger, G. W., and Hodges, C. V. Coexistence of renal tumor and solitary cyst of kidney. *Arch. Surg.*, 1955, *71*, 115–119.
20. Sease, C. J., Jr. Multilocular cyst of kidney with malignant changes. *Virginia M. Month.*, 1953, *80*, 447–450.
21. Triska, H. Ein Fall von Solitärcyste der Niere und Papillom in oberen Nierenbeckenkelch. *Ztschr. f. Urol.*, 1951, *44*, 391–394.
22. Walsh, A. Solitary cyst of kidney and its relationship to renal tumour. *Brit. J. Urol.*, 1951, *23*, 377–379.
23. Zeitel, B. E., Lentino, W., Jacobson, H. G., and Poppel, M. H. Renografin, new intravenous urographic medium. *J. Urol.*, 1956, *76*, 461–465.

THE INTRAVENOUS UROGRAM IN ACUTE LEUKEMIA*

By LEE B. LUSTED, M.D., BYRON E. BESSE, Jr., M.D.,†
and RICHARD FRITZ, M.D.‡
ROCHESTER, NEW YORK

KIDNEY enlargement in patients with acute leukemia usually is attributed to infiltration with leukemic cells.[1,4–7,9,10] However, it has been observed at the Clinical Center that renal enlargement is common in patients dying with acute leukemia and is not necessarily caused by leukemic cell infiltration.[2,3,8]

Since kidney enlargement may or may not be caused by leukemic cell infiltration, we wondered whether intravenous pyelography would enable us to decide which kidneys were enlarged as a result of leukemic infiltration. This paper presents the results of the investigation which was made to answer this question.

MATERIAL AND METHOD

All patients in this study were admitted to the Chemotherapy Service, National Cancer Institute, with a diagnosis of either acute lymphocytic or acute myelogenous leukemia. A total of 85 patients were seen; 41 children and 44 adults. Some patients were acutely ill at the time of admission and died before treatment could be started. All other patients did receive some type of chemotherapy.

Postmortem examination was performed on all patients. A gross and microscopic study of each kidney was made by Dr. Fritz to determine the amount of leukemic cell infiltration. The degree of infiltration was estimated as the fraction of the total kidney weight.

Intravenous urograms were studied of all patients (a) who had kidney enlargement demonstrated on the scout roentgenogram of the abdomen, (b) who had had urography within a thirty day period prior to death, and (c) who did not have a remission during the thirty day period prior to death. Of the 8 (6 children and 2 adults) patients in this group, postmortem examination revealed that 3 had an estimated leukemic cell infiltrate of the kidneys of 75 per cent or greater and 5 had an estimated infiltrate of 20 per cent or less.

Fig. 1. J.P., a sixteen year old female with acute myelogenous leukemia. Postmortem examination showed leukemic infiltration estimated at less than 10 per cent of the weight of the kidney. Most of the infiltration was in the cortex. Interstitial edema, dilatation of tubules and multiple hemorrhages in parenchyma.

ROENTGENOGRAPHIC FINDING

All of the intravenous urograms showed that the calyces and infundibula were elon-

* From the Diagnostic X-ray Department, Clinical Center, and the Chemotherapy Service, National Cancer Institute, National Institutes of Health.
† Present Address: Department of Radiology, Jefferson Medical College, Philadelphia, Pennsylvania.
‡ Present Address: Department of Medicine, The Johns Hopkins University School of Medicine, Baltimore, Maryland.

Fig. 2. C.S., a four year old male with acute lymphocytic leukemia. Leukemic infiltration estimated at less than 10 per cent of the weight of the kidney. Interstitial edema and dilatation of all tubules was found. Cortex was chief site of leukemic infiltration.

gated without real deformity (Fig. 1–4). The renal pelves were enlarged without evidence of obstruction. Some decrease in kidney function was noted in kidneys with and without leukemic infiltration so that this observation could not be used to identify the infiltrated kidneys (Fig. 3 and 4). This roentgen appearance, also described by

Fig. 4. S.M., a three year old male with acute lymphocytic leukemia. Postmortem examination revealed diffuse leukemic infiltration throughout the entire cortex and medulla.

Fig. 3. A.D., a four year old male with acute lymphocytic leukemia. Over 50 per cent of the weight of the kidney was estimated to be leukemic infiltrate. Cortex showed hemorrhage and hemorrhagic necrosis.

Gowdey and Neuhauser,[4] does seem characteristic of the kidney in leukemia but it does not necessarily result from leukemic cell infiltration. The same picture may be observed when the kidney is edematous or the parenchyma contains extensive hemorrhage. One may speculate that some of the kidneys in the 3 nonautopsied cases of leukemia reported by Gowdey and Neuhauser[4] were not infiltrated with leukemic cells.

After the first careful study of the intravenous urograms, all identifying marks on the films were removed. The urograms then were laid aside and after an interval of three weeks they were re-examined.

The authors are convinced from these examinations that it is not possible to definitely identify leukemic cell infiltration in the kidneys from the intravenous urogram.

SUMMARY

Intravenous urography does not help to differentiate the kidney enlargement caused by leukemic cell infiltration from the enlargement caused predominantly by edema or hemorrhage.

Lee B. Lusted, M.D.
Strong Memorial Hospital
260 Crittenden Boulevard
Rochester 20, New York

REFERENCES

1. Anderson, W. A. D., Editor. Pathology. Second edition. C. V. Mosby Company, St. Louis, 1953, p. 584.
2. Besse, B. E., Jr., Leiberman, J. E., and Lusted, L. B. Kidney size in acute leukemia. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1958, *80*, 611–617.
3. Fritz, R., Frei, E., Besse, B. E., Jr., and Lusted, L. B. Renal disease in acute leukemia. To be published.
4. Gowdey, J. F., and Neuhauser, E. B. D. Roentgen diagnosis of diffuse leukemic infiltration of kidneys in children. Am. J. Roentgenol. & Rad. Therapy, 1948, *60*, 13–21.
5. Kirshbaum, J. D., and Preuss, F. S. Leukemia; clinical and pathologic study of 123 fatal cases in series of 14,400 necropsies. *Arch. Int. Med.*, 1943, *71*, 777–792.
6. Merrill, D., and Jackson, H., Jr. Renal complications of leukemia. *New England J. Med.*, 1943, *228*, 271–276.
7. Pentecost, C. L., and Pizzolato, P. Involvement of genito-urinary tract in leukemia; with report of case of involvement of urinary bladder. *J. Urol.*, 1945, *53*, 725–731.
8. Sternby, N. H. Studies in enlargement of leukaemic kidneys. *Acta haemat., Basel*, 1955, *14*, 354–362.
9. Watson, E. M., Sauer, H. R., and Sadugor, M. G. Manifestations of lymphoblastomas in genitourinary tract. *J. Urol.*, 1949, *61*, 626–645.
10. Wintrobe, M. M. Clinical hematology. Fourth edition. Lea & Febiger, Philadelphia, 1956, p. 938–939.

VOL. 80, NO. 4

KIDNEY SIZE IN ACUTE LEUKEMIA*

By BYRON E. BESSE, JR., M.D.,† JACOB E. LIEBERMAN, M.S., *and* LEE B. LUSTED, M.D.‡
ROCHESTER, NEW YORK

A NUMBER of papers have been written dealing with the size of kidneys measured on roentgenograms or at postmortem examination. Moëll[7] refers to several of these in his article on the size of normal kidneys. This article is of considerable interest because it gives "normal" values which were obtained from a comparatively large series of observations, and it gives certain conclusions on sex and left and right kidney differences.

Some patients with acute leukemia have enlarged kidneys while some do not. As part of an extensive and continuing study on patients with acute leukemia,[2,5] we have measured kidney size on a series of roentgenograms.

The purpose of this paper is to evaluate Moëll's method of measurement on kidneys of patients with leukemia and to ascertain whether the conclusions reached by Moëll hold for the group under consideration.

MATERIAL AND METHOD

The material consisted of 38 patients, 22 children and 16 adults, with acute leukemia, who were admitted on the Chemotherapy Service, National Cancer Institute (Table VII and VIII). All patients received chemotherapy except the few who were acutely ill on admission and died before treatment could be started.

Scout roentgenograms of the abdomen were taken in the standard anteroposterior projection with a uniform target film distance of 100 cm. The maximum length and maximum width of the kidney were measured independently on four occasions (by B.E.B. and L.B.L.) following the procedure described by Moëll.

The median examination time of the series was fourteen days prior to death and no examination was included which was obtained more than ninety days prior to death.

The area of the kidney was estimated in two ways by Moëll: (1) by using the formula for the area of an ellipse $A=\pi(\frac{1}{2}$ length$)\times(\frac{1}{2}$ width) and (2) by measuring the kidney area with a planimeter. He found a good agreement between the areas. In this paper the areas are those calculated by the ellipse formula from direct measurements of kidney length and width. The standard deviation (S) is shown for the kidney dimensions and kidney area.

A postmortem examination was performed on all patients. A gross and microscopic inspection of each kidney was made by Dr. Richard Fritz[2] of the National Cancer Institute, and an estimate was made of the degree of leukemic cell infiltration as a percentage of total kidney mass.

The results obtained in the present investigation are recorded in Tables I to VIII.

SIZE OF THE KIDNEYS

An analysis of our data, which are partially summarized in Table I, confirmed the conclusions of Moëll's paper. The data on roentgenographic measurements of area on the kidneys of leukemic children showed that: (1) the kidneys were smaller in the female children than in the male children. The sex difference for the sample of patients under consideration was statistically significant; and (2) in both sexes the left kidney was somewhat larger than the right. This statement is made to parallel that of Moëll. If the word "somewhat" as used by Moëll is intended to mean nonsignificance in the statistical sense then this statement can also be confirmed by the data at hand.

* From the Diagnostic X-ray Department, Clinical Center and Biometrics Branch, Division of Research Services, National Institutes of Health.
† Present address, Department of Radiology, Jefferson Medical College Hospital, Philadelphia, Pennsylvania.
‡ Present address, Department of Radiology, Strong Memorial Hospital, Rochester, New York.

TABLE I

SIZE OF KIDNEYS OF LEUKEMIC CHILDREN AS MEASURED FROM ROENTGENOGRAMS BY SEX AND SIDE

Sex	Right			Left			Total Area
	Length	Width	Area	Length	Width	Area	
	cm.	cm.	cm.^{2}	cm.	cm.	cm.^{2}	cm.^{2}
♀	11.5	5.6	51.8	12.0	5.8	56.3	108.1
S	2.3	0.80	18.1	2.3	1.1	22.1	39.7
♂	12.6	6.6	69.1	12.8	6.5	69.3	138.4
S	2.8	1.9	36.1	3.0	1.9	36.3	71.9

As a matter of fact, it can be stated from an analysis of these data that after a random selection of a subject has been made, there is approximately a fifty-fifty chance that the left kidney would measure larger than the right kidney.

The data for adults which are partially summarized in Table II also confirmed Moëll's conclusion that a sex difference in size of kidneys does exist; however, Moëll's statement concerning left and right kidney size differences does not agree with our data. It can be seen from Table II that for females, the average area of the right kidney of 71.4 cm.^{2} is larger than the area of the left kidney of 64.6 cm.^{2}. This undergoes a reversal for the males, where the average right kidney size is 78.5 cm.^{2} and the left kidney size is 81.9 cm.^{2}.

Since right-left kidney differences are unimportant, the left-right differentiation was omitted from Table III which compares the total kidney areas obtained by Moëll and the present series.

An attempt was made to compare Moëll's data with the present data, statistically. However, it was difficult to assign a clear meaning to the "S" value given by Moëll in his tables.

MASS OF THE KIDNEYS

Moëll's article states that Thoma found the left kidney 5 to 7 per cent heavier than the right kidney with the total average mass of 316 gm. in males and 292 gm. in females. It is also stated that Roessle and Roulet found the kidney mass in adult males (from twenty to fifty-five years) to be in the range of 260–280 gm. and in females in the range of 240–260 gm.

The masses of the kidneys found in the present study are summarized in Tables IV and V. These were wet masses obtained at autopsy.

As may be noted, the average kidney mass of females was about 82 per cent of the average male kidney mass and the average children's kidney mass was ap-

TABLE II

SIZE OF KIDNEYS OF LEUKEMIC ADULTS AS MEASURED FROM ROENTGENOGRAMS BY SEX AND SIDE

Sex	Right			Left			Total Area
	Length	Width	Area	Length	Width	Area	
	cm.	cm.	cm.^{2}	cm.	cm.	cm.^{2}	cm.^{2}
♀	13.4	6.7	71.4	13.0	6.3	64.6	136.0
S	1.4	1.1	17.4	1.6	0.9	13.1	28.9
♂	14.4	6.9	78.5	14.8	7.0	81.9	160.4
S	0.9	0.9	12.4	1.1	0.9	15.1	29.8

TABLE III

COMPARISON OF TOTAL KIDNEY AREAS (CM.^{2}) OBTAINED BY MOËLL AND IN THE PRESENT SERIES

Sex	Moëll	Present Series	
		Adults	Children
Female	119.3	136.0	108.1
Male	129.6	160.4	138.3

TABLE IV

AVERAGE MASS OF KIDNEYS (GM.) FOR CHILDREN AND ADULTS BY SEX

	Children	Adults	Sex
Male	213.1	240.5	225.3
Female	154.7	218.7	185.2
Age	183.9	231.9	—

proximately 79 per cent of the average adult kidney mass. The left-right mass distinction, however, was not too clear.

For both children and adults, the left kidney on the average was heavier than the right kidney (185.4 to 182.5 for children and 235.0 to 228.7 for adults). Note, however, that this mass difference was not uniform for sex or age and that reversals in kidney mass occurred within sex and age. In view of these reversals it is doubtful whether the left-right mass difference can be established.

SIZE OF THE KIDNEYS RELATED TO BODY SIZE

Moëll states, "The total area of the kidneys in females was smaller than in males with a probability of 99 per cent but, on correlation with m.^{2} body surface, this difference was not statistically significant." The implication is that "the shape of the kidney, like, for example, the shape of the heart corresponds to general body build." This is a recognition of the fact that a comparison of kidney area between male and female may be mainly a comparison of body size, and, of course, the female kidney will be shown to be smaller than the male kidney.

TABLE VI

ANALYSIS OF ERROR VARIANCE IN ADULT DATA

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Within sex, unadjusted sizes	13	5,905.27	
Reduction due to regression of body mass	1	1,156.26	1,156.26
Errors for adjusted gains	12	4,749.01	395.75

$$F = \frac{1{,}156.26}{395.75} = 2.92$$

Because it is difficult to obtain m.^{2} body surface, under most conditions, particularly if an accurate measurement is desirable and necessary, body mass has been substituted for body surface. Thus, using mass as the concomitant variable, the standard procedure of regression analysis[9] can be used to test whether female and male kidneys differ in size, independently of differences in male and female body sizes. For these samples of leukemic children and adults, the adjustment of the data to body mass still leaves a sex difference in size of kidneys. Table VI shows that the re-

TABLE V

AVERAGE MASS OF KIDNEYS (GM.) FOR CHILDREN AND ADULTS BY SEX AND LEFT-RIGHT SIDE

	Children			Adults		
	Male	Female	Both Sexes	Male	Female	Both Sexes
Left	211.3	159.5	185.4	251.2	218.7	235.0
Right	215.0	150.0	182.5	229.7	227.7	228.7

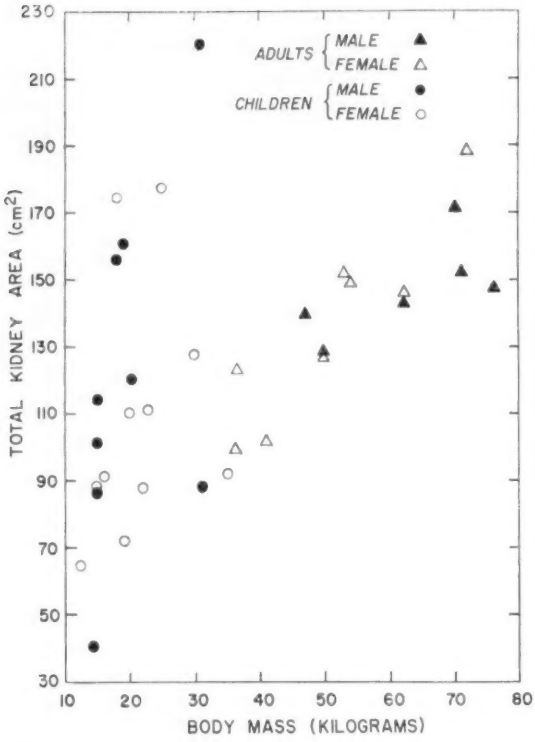


FIG. 1. Total kidney area versus body mass in adults and children with acute leukemia. A linear relationship is demonstrated between total body mass and total kidney area.

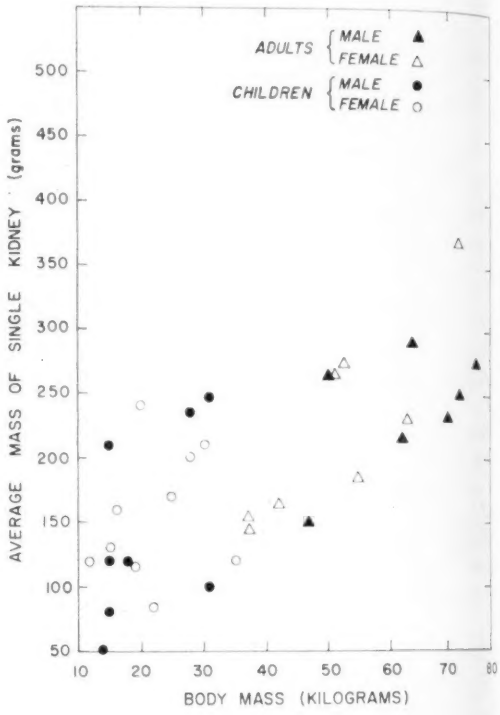


FIG. 2. Average mass of a single kidney versus total body mass in adults and children with acute leukemia. Note that the regression lines for adults and children are nearly parallel.

duction of the sum of squares of the unadjusted kidney size is not statistically significant.

Figure 1 shows the relationship between kidney area and body mass. It is obvious that a large part of the variability in the total kidney mass is accounted for by differences in body mass. Another way of saying this is that there is a functional relationship, in this case a linear relationship, between total kidney area and body mass. This relationship is different for adults and children; the slope of the linear relationship for the children is much steeper than the slope of the linear relationship for the adults. This means that the kidney area increment per unit body mass is larger for the child kidney than for the adult kidney. It seems safe to state that the male and female area-mass relationships are parallel in both children and adults.

Figure 2 gives the regression of kidney mass on body mass. The kidney mass used here is the average of the left and right kidney masses. The conclusions stated in the previous paragraph on the regression of kidney area on body mass hold also for the data in Figure 2.

A possible answer to the question, whether the area as determined from the roentgenogram is indicative of the "real" substance comprising the kidney may be obtained from Figure 3. In this graph, kidney size is plotted against the kidney mass. In order to keep the dimensionality the same for the ordinate and abscissa, the masses have been transformed to a pseudo-mass which consisted of the two-thirds power of the mass. The graph clearly indicates the direct relationship between kidney size and kidney mass, and therefore any of our conclusions which were based on

TABLE VII

DATA ON ADULTS WITH ACUTE LEUKEMIA

Patient	Sex	Age	Dimension of Kidneys		Area of Kidneys		Total Area of Kidneys	Area of Body Surface	Infiltration	Mass of Kidneys		Last Film Prior Autopsy
			R	L	R	L				R	L	
		yr.	cm.	cm.	cm.^{2}	cm.^{2}	cm.^{2}	m.^{2}	Per Cent	gm.	gm.	da.
P.B.	M	30	14.4×6.5	14.6×5.9	73.5	67.6	141.1	1.57	less 5	150	150	35
S.B.	M	56	14.6×7.5	14.7×7.8	86.0	90.0	176.0	—	less 25–30	230	270	8
A.C.	M	22	14.8×6.5	14.8×6.6	75.5	76.7	152.2	—	less 5	250	250	18
G.C.	M	52	16.0×8.9	16.5×8.6	111.8	111.4	223.2	—	10–20	260	320	5
S.D.	F	30	13.0×6.3	13.2×6.0	64.3	62.2	126.5	1.53	0	270	240	7
M.F.	F	78	13.2×7.4	12.9×6.9	76.7	69.9	146.6	1.71	0	245	215	11
M.G.	F	46	11.5×5.8	11.1×5.7	52.4	49.7	102.1	1.33	0	170	160	1
R.H.	F	34	14.7×6.1	15.4×6.7	70.4	81.0	151.4	—	20	250	300	3
N.M.	F	48	13.1×8.4	10.9×7.4	86.4	63.3	149.7	1.51	0	180	90	33
M.P.	F	70	12.7×5.4	12.5×4.8	53.8	47.1	100.9	1.33	30	162	150	42
F.P.	M	42	12.8×6.4	12.9×6.4	64.3	64.8	129.1	1.58	less 10	250	280	20
L.P.	M	45	13.5×6.3	13.6×7.1	66.8	75.8	142.6	1.66	10	208	220	3
G.S.	M	39	14.8×6.0	15.2×6.5	69.7	77.6	147.3	1.98	less 5–10	280	270	75
L.S.	F	29	16.2×8.2	15.0×7.1	104.3	83.6	187.9	1.84	less 10	410	340	9
A.S.	M	47	14.2×7.2	15.7×7.4	80.3	91.2	171.5	1.83	10–15	210	250	20
A.V.	F	33	12.9×6.2	13.0×5.9	62.8	60.2	123.0	1.26	less 5	135	155	49

kidney size would hold when kidney mass is substituted for kidney size.

Since there is a direct relationship between kidney size and kidney mass, it is possible to proceed one step further by asking whether there is a relationship between kidney size and degree of leukemic cell infiltration. Figure 4 shows the results of this study and indicates that the amount of kidney enlargement is not necessarily related to the degree of infiltration. Because at autopsy the kidneys were found to be enlarged and to contain leukemic cells,[1,4,6,8,11,12] it should not be assumed that the renal enlargement demonstrated on the scout roentgenograms of the abdomen must be caused by leukemic infiltration.[3] Frequently, edema and parenchymal hemorrhage are the cause of renal enlargement in acute leukemia patients.[10]

All conclusions in this paper should have the modifying phrase "for this set of data."

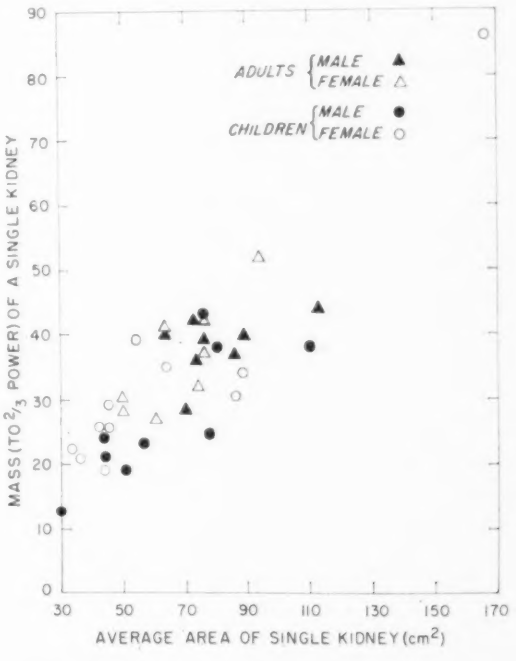
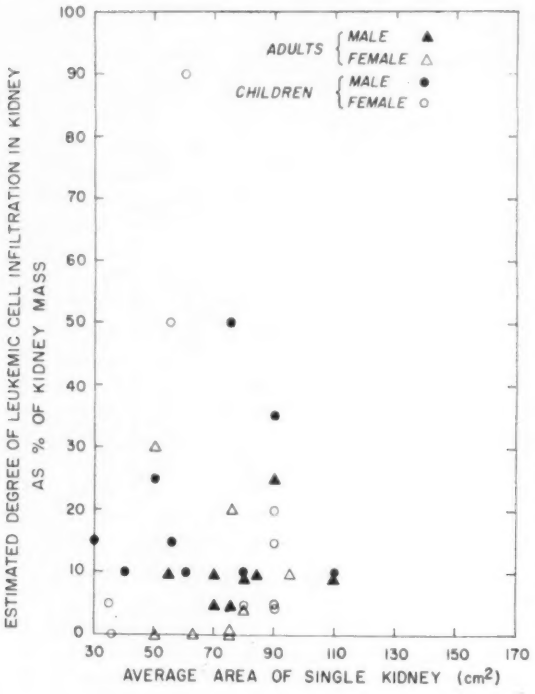


FIG. 3. Mass (to the 2/3 power) of a single kidney versus the average of a single kidney for leukemic adults and children. Note the parallel relation for adults and children.

DISCUSSION

The patients under study were not se-



lected at random, nor were they representative of the leukemic population under some restricted random sampling. In compiling our data, we did not consider the following points: (1) Uniformity of time between diagnosis and abdominal roentgenography, and (2) type of treatment and duration of treatment of each patient prior to the time of roentgen examination.

Such considerations are important because future studies with these points in mind may indicate whether or not change in kidney size is a reliable indicator of leukemic therapy efficacy. However, the data for this study are adequate to support the

Fig. 4. Estimated degree of leukemic cell infiltration versus average area of the kidneys. Note that kidney size does not give an indication of the amount of leukemic cell infiltration.

Table VIII

DATA ON CHILDREN WITH ACUTE LEUKEMIA

Patient	Sex	Age	Dimension of Kidneys		Area of Kidneys		Total Area of Kidneys	Area of Body Surface	Infiltration	Mass of Kidneys		Last Film Prior Autopsy
			R	L	R	L				R	L	
		yr.	cm.	cm.	cm.²	cm.²	cm.²	m.²	Per Cent	gm.	gm.	da.
J.B.	F	11	15.0×6.9	15.6×7.8	81.3	95.5	176.8	0.99	less 15	160	180	83
F.B.	M	12	15.5×8.6	17.1×8.5	104.7	114.1	218.8	1.16	less 10	240	250	23
A.B.	M	31 mo.	10.2×5.0	11.4×5.2	40.0	46.5	86.5	0.61	33	140	100	2
D.C.	M	7	18.0×11.4	17.5×11.3	161.1	155.2	316.3	0.93	100	820	770	8
M.C.	F	12	13.4×5.9	13.5×6.1	62.1	64.6	126.7	1.12	large	190	230	30
A.D.	M	4	13.6×6.7	14.8×6.4	71.5	74.4	145.9	—	over 50	270	290	31
S.G.	F	3	10.0×5.1	9.3×4.4	40.0	32.1	72.1	—	0	120	110	1
W.G.	M	2	12.0×5.3	11.9×5.5	49.9	51.4	101.3	0.56	25	85	80	48
R.H.	M	9	11.2×5.1	11.5×4.9	44.8	44.2	89.0	1.08	less 5–10	90	105	1
B.H.	F	6	10.8×5.5	13.1×6.1	46.6	62.7	109.3	0.78	over 50	240	240	9
A.H.	M	8	12.2×6.3	11.2×5.8	60.5	51.0	111.5	—	15–20	—	—	6
H.L.	M	8	14.2×6.5	15.4×7.2	72.5	87.0	159.5	1.10	less 10	210	260	39
M.M.	M	16 mo.	6.4×3.7	6.7×3.8	18.6	20.0	38.6	0.52	10–20	45	48	7
S.M.	M	3	12.4×6.8	11.0×5.6	66.2	48.4	114.6	0.63	—	130	90	59
T.M.	F	3	9.6×5.4	11.0×5.7	40.7	49.2	89.9	0.61	—	150	170	31
L.M.	F	7	10.0×5.0	11.7×5.2	39.3	47.8	87.1	0.69	less 10	130	130	2
R.M.	F	4	9.1×4.7	9.0×4.4	33.6	31.1	64.7	—	less 5	120	120	50
J.P.	F	16	15.5×7.0	15.3×7.5	85.2	90.1	175.3	—	less 10	190	210	34
C.S.	M	4	14.3×7.1	13.1×7.5	79.7	77.1	156.8	0.69	less 10	120	120	4
B.S.	F	9	11.6×5.0	11.2×4.8	45.5	42.2	87.7	0.92	less 5	80	85	4
S.S.	F	7	10.4×5.3	10.3×5.9	43.3	47.7	91.0	1.12	15–25	120	120	14
E.T.	M	3	11.6×6.5	12.3×6.4	59.2	61.8	121.0	0.75	less 10	—	—	16

conclusions on kidney size with respect to sex differences and adult and children differences. Also these data provide nearly ideal material by which to test Moëll's methods and procedure.

Moëll considers "normal" kidney size, "normal" kidney weight, etc. The question arises as to whether such consideration of normal is feasible. It is our experience that observer bias in measurement does occur; that two observers measuring the same roentgenogram often will have different answers and that this difference is not happenstance but statistically significant. Each observer may have a constant bias in measurement of roentgenograms. If an observer measures the size of the kidneys of a patient before and after treatment, his measurement error is the same for the before and after films. But the difference caused by treatment is independent of the observer. Thus, the use of roentgenograms for measurement of kidney size can be helpful to detect differences in kidney size.

CONCLUSIONS

1. Measurements of kidney size from the scout roentgenogram of the abdomen give a valid indication of kidney size and mass.

2. The extent of kidney enlargement in a patient with acute leukemia is not related to the degree of leukemic cell infiltration.

Lee B. Lusted, M.D.
Strong Memorial Hospital
260 Crittenden Boulevard
Rochester 20, New York

REFERENCES

1. Anderson, W. A. D. Editor. Pathology. Second edition. C. V. Mosby Company, St. Louis, 1953, p. 584.
2. Fritz, R., Frei, E., Besse, B. E., Jr., and Lusted, L. B. Renal disease in acute leukemia. To be published.
3. Gowdey, J. F., and Neuhauser, E. B. D. Roentgen diagnosis of diffuse leukemic infiltration of kidneys in children. Am. J. Roentgenol. & Rad. Therapy, 1948, *60*, 13–21.
4. Kirshbaum, J. D., and Preuss, F. S. Leukemia; clinical and pathologic study of 123 fatal cases in series of 14,400 necropsies. *Arch. Int. Med.*, 1943, *71*, 777–792.
5. Lusted, L. B., Besse, B. E., Jr., and Fritz, R. Intravenous urogram in acute leukemia. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1958, *80*, 608–610.
6. Merrill, D., and Jackson, H., Jr. Renal complications of leukemia. *New England J. Med.*, 1943, *228*, 271–276.
7. Moëll, H. Size of normal kidneys. *Acta radiol.*, 1956, *46*, 640–645.
8. Pentecost, C. L., and Pizzolato, P. Involvement of genito-urinary tract in leukemia; with report of case of involvement of urinary bladder. *J. Urol.*, 1945, *53*, 725–731.
9. Snedecor, G. W. Statistical Methods. The Iowa State College Press, Ames, Iowa. Fifth edition.
10. Sternby, N. H. Studies in enlargement of leukaemic kidneys. *Acta haemat., Basel*, 1955, *14*, 354–362.
11. Watson, E. M., Sauer, H. R., and Sadugor, M. G. Manifestations of lymphoblastomas in genitourinary tract. *J. Urol.*, 1949, *61*, 626–645.
12. Wintrobe, M. M. Clinical Hematology. Fourth edition. Lea & Febiger, Philadelphia, 1956, p. 938–939.

SIMULTANEOUS CHOLECYSTOGRAPHY AND UROGRAPHY WITH A NEW MEDIUM "DUOGRAFIN"*

By THEODORE L. ORLOFF, M.D.
PHILADELPHIA, PENNSYLVANIA

FOLLOWING the introduction of cholografin, it was possible to visualize the hepatic and common ducts in cholecystectomized patients. Recently a new radiopaque preparation for simultaneous visualization of the biliary and renal systems (Fig. 1) was introduced (duografin†). It is a mixture containing 40 per cent renografin for urography, and 20 per cent cholografin for cholecystography and choledochography, both media present as the methylglucamine salt in aqueous solution.

Duografin contains in each cubic centimeter 400 mg. of renografin acid, 200 mg. of cholografin acid and 198 mg. of methylglucamine. Chemically renografin acid is 3, 5-diazetylamino-2,4,6-triiodobenzoic acid; cholografin acid is N-N′-adipyl-bis (3-amino-2,4,6-triiodobenzoic acid). Renografin acid contains 62.1 per cent of bound iodine; cholografin acid contains 66.8 per cent; and the solution supplied as duografin, 38.2 per cent or 382 mg. of bound iodine per cubic centimeter. The solution has a pH of 7.22 and a specific gravity of 1.430. The viscosity of duografin is 28 centipoises.

Following intravenous administration, renografin is carried to the kidneys and excreted in sufficient concentration to permit optimum opacification of the renal structures within seven minutes. Cholografin, following intravenous administration, is carried to the liver where it is rapidly secreted. The cholografin reaches optimum opacification in fifteen minutes, permitting visualization of the hepatic and common ducts. The gallbladder is visualized best within two to two and one-half hours (Fig. 2).

TECHNIQUE OF EXAMINATION

The examination is best carried out in the morning. The patient is instructed to have nothing to eat or drink after retiring the night before; however, a laxative, such as castor oil or compound licorice powder may be taken.

Fifty milligrams of pyribenzamine is given orally thirty minutes to one hour before the examination. Those patients with histories of drug reactions, asthma or hay fever should be tested with care. The test is made by slowly injecting intravenously 1 cc. of a test solution and observing for one half hour for any sign of hypersensitivity.

The solutions should be warmed to room temperature and given by intravenous injection over a period of five to ten minutes. Thirty to forty cubic centimeters of the medium are used in order to obtain optimum contrast. The supine position with the left side elevated is used for duct visualization. The usual technique is employed for roentgenography of the kidneys, ureters and bladder.

TOXICITY

Animal. In tests carried out at the Squibb Institute for Medical Research,[1] duografin was injected intravenously into 10 mice in single doses equivalent to 3,162 and 1,608 mg. per kg. of body weight of the methylglucamine salts of renografin and of cholografin, respectively. No deaths occurred during the ten day observation. Four days after the injection, one mouse exhibited signs of middle ear infection which persisted throughout the ten days. No abnormal signs were observed in the other 9 mice during the test period.

Man. In general, experience indicates that both major components of duografin are well tolerated. Nausea and, on occasion, vomiting appear to be the major symptoms of toxic effects.

† E. R. Squibb & Sons.

* From the Department of Radiology, Albert Einstein Medical Center, Northern Division, Philadelphia, Pennsylvania.

Fig. 1. Simultaneous visualization of the common duct and urinary tract after intravenous injection of duografin.

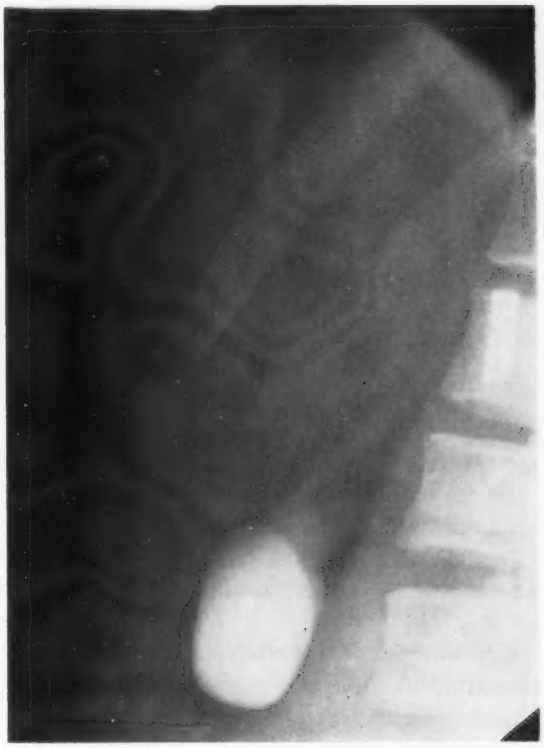


Fig. 2. Satisfactory visualization of gallblader after intravenous injection of duografin.

REACTIONS

No instance of a severe reaction has been observed in a series of 25 cases. Such reactions as warmth, venous pain, urticaria, nausea or vomiting have not been observed.

RESULTS

Twenty-five cases have been examined. The common duct was visualized in all but one case. The urinary tract was visualized in all cases. Visualization of the common duct was, for the main part, only fair. Common duct visualization was fair in 17 cases and good in 7. The intravenous urograms were considered satisfactory.

SUMMARY

A new compound for simultaneous intravenous urography, choledochography and cholecystography is described. The use of this medium is indicated in abdominal diagnostic problems where the history suggests involvement of either the biliary or renal systems or in routine physical examinations where time is a factor.

8665 Clifton Way
Beverly Hills, California

REFERENCE

1. Hunt, W. H. H. Report of pharmacological tests. The Squibb Institute of Medical Research, January 27, 1956.

URETEROCELE: ROENTGENOLOGIC DIAGNOSIS WITH REPORT OF AN UNUSUAL CASE

By JOSEPH SELMAN, M.D.*
TYLER, TEXAS

ALTHOUGH the subject of ureterocele has been frequently reviewed in journals of urology and general surgery,[1,2,5,8,9,10] it is rarely encountered in the radiologic literature. Because of this, it was considered worthwhile to discuss briefly the salient features of this important urologic condition, especially since the radiologist may be the first in line to make the diagnosis and thereby prevent irreparable damage to the upper urinary tracts. In addition, an unusual example occurring in an infant recently seen by the author will be reported.

Ureterocele may be defined as a cystic dilatation of the lower end of the ureter associated with orificial stenosis and prolapse of the cyst into the bladder. This condition was first described in 1834 by Lechler who incorrectly believed it to represent a double bladder. The first case to be diagnosed through the cystoscope was reported by Grosglik in 1901.[8] The term ureterocele came into general use about 1912. Thus, it has been recognized as a clinical entity for nearly sixty years, frequent reports having appeared in the urologic journals during this time.

INCIDENCE

According to Rhodes,[10] the incidence of ureterocele is about 2 per cent of cystoscopies, agreeing well with Campbell's[2] figure of 1 to 2 per cent. Thus, it is by no means a rare disorder.

SEX DISTRIBUTION

Most authorities agree that ureterocele is about 3 to 4 times as common in females as in males, this being similar to our own experience.

ETIOLOGY

There is no consensus as to the cause. The most plausible and also the most popular explanation indicts congenital stenosis of the ureteral orifice, associated with deficient connective tissue and smooth muscle elements in the lower intramural ureter adjacent to the meatus. The stenosis probably results from failure of absorption of a normal embryonic structure—the ureteral membrane—in the 22 mm. embryo. This embryologic defect was actually observed by Chwalle[3] in a human embryo and reported in a classic paper (1927). The congenital origin of ureterocele is supported by the fact that other urogenital anomalies are found in 70 per cent of patients harboring ureterocele.[5] According to Campbell,[1,2] there is ipsilateral complete duplication of the urinary tract in about one-third of ureteroceles, and contralateral duplication in about one-eighth. About 15 per cent of patients with ureterocele have it bilaterally. In two-thirds of the cases with double kidney associated, the ureterocele drains the upper kidney.

PATHOLOGY

A ureterocele is essentially a cyst of the intramural ureter composed of two layers. The *inner* layer is derived from the ballooned ureteral mucosa, while the *outer* layer represents the bladder mucosa carried downwards on the surface of the prolapsing ureter. The two layers meet at the stenotic ureteral orifice (Fig. 1*B*). Between the two layers are found a few connective tissue elements and perhaps an occasional smooth muscle cell. The orifice, which is really the downward displaced ureteral meatus, may lie at the apex of a small ureterocele, but as the cyst enlarges, the orifice may be shifted inferiorly and posteriorly so that it is no longer visible through the cystoscope. The cyst may remain small throughout life, but

* Radiology Department, Medical Center Hospital, Tyler, Texas.

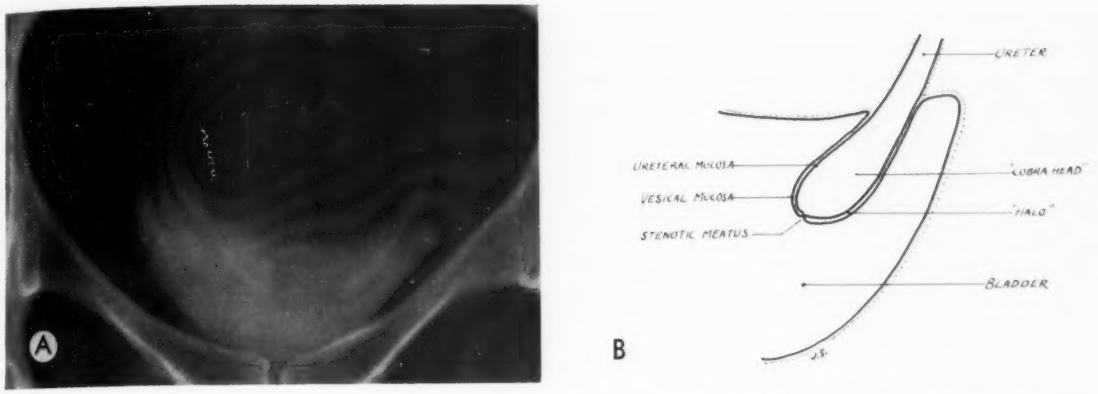


Fig. 1. (*A*) Bilateral ureteroceles in a woman. The left ureterocele, which is larger than the right, presents the typical cobra head sign surrounded by a radiolucent halo. (*B*) Diagrammatic representation of the left ureterocele. The inner wall of the cyst is a continuation of ureteral mucosa. The outer wall is a continuation of bladder mucosa. Both layers meet at the stenotic, displaced meatus.

occasionally it may reach a size sufficient to fill the bladder, even herniating through the urethra.[4,6]

It is the secondary renal damage brought about by the ureterocele that is of such serious consequence. The progressive increase in back pressure in the ureter eventually leads to hydronephrosis. If the ureter is duplicated, only the segment of kidney drained by its ureter is affected. However, if the ureterocele is large enough, it may also block the adjacent duplicated ureteral orifice and cause hydronephrosis of the duplicated kidney. If the condition is not recognized early and infection supervenes, the kidney is eventually destroyed. Rarely, a ureterocele may block the bladder neck and produce bilateral hydronephrosis.

Another complication is the occurrence of stones. According to Lowsley and Kirwin,[8] calculi occur in 4 per cent of ureterocele patients—an incidence significantly above that in the general population. A stone not infrequently forms, or at least is found in the ureterocele itself (Fig. 2).

CLINICAL FINDINGS

The clinical manifestations of ureterocele obviously depend on the stage of involvement of the urinary tract by secondary changes. There are three stages in the progress of the disease: ureteral obstruction, hydronephrosis, and infection. During the initial phase of ureteral obstruction, in which there is simple urinary stasis, the patient may have no complaints because of the insidious onset and progress. At most, the patient may complain of vague abdominal, pelvic, or lumbar discomfort. Even in the presence of hydronephrosis, complaints may be minimal.

When infection occurs, the clinical picture may be considered from the standpoint of general complaints, namely, fever and malaise; and localized complaints referable to the bladder, manifested by pain, dysuria, hesitancy, frequency, dribbling, urgency, and nocturia. When the ureterocele blocks the urethra, there may be intermittency of the stream, the patient discovering that urination is more easily ac-

Fig. 2. Opaque calculus in a ureterocele, having the same configuration as the cyst. A large laminated stone is present in the bladder.

complished in the knee-chest position. In infants and children, enuresis may be the first sign noted by the parents. Pyuria which is persistent and fails to respond promptly and permanently to antimicrobial therapy should be the clue to serious involvement of the urinary tract, such as pyonephrosis. Immediate careful urologic study should reveal the correct diagnosis and prevent progression of the disease, if it has not already advanced to hydronephrosis and pyonephrosis with irreversible renal damage.

Any patient developing hematuria in the presence of a ureterocele should be suspected of harboring a urinary tract stone,[12] although bleeding may rarely occur in the absence of a complicating stone.

ROENTGEN FINDINGS

At least 50 per cent,[5] and possibly as many as 85 per cent[1] of ureteroceles can be diagnosed on the basis of carefully performed excretory urography with any of the standard urographic media. Furthermore, this procedure reveals the functional status of the urinary tracts and may disclose other urinary tract abnormalities such as anomalies or stones. The roentgen diagnosis rests on the demonstration of a characteristic *spring onion* or *cobra head* shaped opacity near the ureteral orifice in the *opacified* bladder. The cobra head represents the ureterocele cyst containing contrast material, separated from the opacified bladder by a thin dark line or *halo*. These two signs—the cobra head and the halo—constitute the diagnostic criteria for the ureterocele of average size. In order for these two signs to be present, there must first be adequate function of the associated kidney, and second, opaque medium in the bladder. If the kidney draining through the ureterocele is not functioning and contrast medium is present in the bladder, the ureterocele appears as a radiolucent defect. If the ureterocele is opacified and there is no contrast medium in the bladder, then the cobra head sign will be present but there will be no halo. The halo actually represents the double-layered wall of the cyst (Fig. 1, *A* and *B*).

Fig. 3. Bilateral ureteroceles in a woman. The ureters are tortuous and remain filled with opaque medium (excretory urography), indicating chronic obstruction. There is no appreciable hydronephrosis.

The size of the defect depends on the size of the ureterocele producing it. It may vary from a barely perceptible bulge of the ureteral meatus to a defect which nearly fills the bladder.

Ureteral dilatation may be very marked in long standing severe obstruction, and if renal damage is serious enough, there may be no concentration of the opaque medium. On the other hand, in adults with small ureteroceles, the ureter may show only elongation and tortuosity without perceptible ectasia (Fig. 3). The presence of associated anomalies such as duplication of the kidneys and ureters helps establish the diagnosis in questionable cases.

In the event that there is inadequate

function of the kidney above a ureterocele, the urinary tract will not be opacified and the diagnosis missed on excretory urography. If the ureterocele is visualized through the cystoscope, the cyst incised, and a catheter sewn in place, opaque medium can be injected and the status of the urinary tract determined, in addition to proving the existence of a ureterocele.

The majority of ureteroceles are found in adults. These are usually small, causing only slight to moderate urinary stasis which may be associated with previously unexplained chronic urinary tract infection. Such instances are usually discovered incidentally during routine examination. In some cases, the ureterocele is found during a search for calculi.

In small children and infants, when ureterocele causes urinary tract disturbances of clinical importance, it is usually severe in degree. Roentgenographically, the ureterocele may present as a large, spherical, smooth defect, centrally or excentrically placed on the floor of the bladder.[2] It may resemble the water-filled bag of a Foley catheter. Such a ureterocele does not contain contrast medium because its kidney is functionless and the cyst therefore stands out as a radiolucent defect in the bladder which has been opacified by the contrast substance excreted by the other kidney.

CYSTOSCOPIC FINDINGS

A small ureterocele appears as a cyst which, when filled, squirts urine through the tiny orifice. However, if the cyst happens to be empty it may resemble a small papilla and the diagnosis missed. This is particularly apt to occur if the bladder is overdistended during cystoscopy. Therefore, the need of preliminary excretory urographic studies must be emphasized. A very large ureterocele presents cystoscopically as a veil or membrane obscuring a portion of the bladder. The meatus may not be recognized if it has become displaced inferiorly and posteriorly.

The author recently encountered an unusual example of ureterocele in an infant, presenting as a large radiolucent defect in the bladder base, a report of which follows.

REPORT OF A CASE

First Admission. The patient was an eighteen month old girl, admitted to Medical Center Hospital on April 15, 1957. The mother had noticed for several months that the child cried out during urination and accomplished this with a great deal of straining. There were frequent episodes of fever. A pediatrician found pyuria which failed to respond to penicillin. One month before admission the mother found "mucinous material" in the urine which she was certain did not arise from the vagina. One week before entry there was marked increase in pain and straining on urination. Because of the continued pyuria, the child was referred to Dr. Fred Warren for urologic study.

On admission, history and physical examination other than that already described were not significant. The urethra was found to be snug to a No. 8 Coudé woven catheter, which hung slightly at the bladder neck. Two ounces of catheterized urine obtained thirty minutes after voiding was clear, contained no mucus, albumin, or reducing sugar; pH 4.5; specific gravity 1.025. Microscopic examination revealed 15 to 20 leukocytes per high power field.

On April 16, cystoscopy was performed by Dr. Warren under general anesthesia. He reported the bladder mucosa to be normal except for increased trabeculation. Bladder capacity was at least 200 cc. The right ureteral orifice was not visualized, but a bulge similar to a ureterocele was found in this area. No efflux could be detected. When the cystoscope was withdrawn to the bladder neck, a curtain of tissue was seen dropping into the bladder neck from 11 o'clock extending around clockwise to 6 o'clock posteriorly. The left ureteral orifice was obscured.

Roentgen Examination. Cystography was done first. There was occult spina bifida of T_{11}. The bladder was tremendously enlarged, reaching the second lumbar vertebra (Fig. 4). A smooth concave radiolucent defect filled the base of the bladder centrally, measuring 3.5 cm. in diameter. There was no ureteral reflux. Excretory urography with neo-iopax (Fig. 5) showed a hydronephrotic double kidney on the right side with at least partial duplication of the upper ureter (later found to be complete);

Fig. 4. Author's case. Cystogram depicting tremendous dilatation of the bladder with a central basal radiolucent defect due to large ureterocele of the left ureter.

this ureter (or ureters) entered the bladder through a possible diverticulum (ureterocele on that side not recognized). On the left side, the lower renal pelvis of a double kidney was normal, but the possibility was considered that there was a nonfunctioning upper kidney. Retrograde pyelography could not be done because the ureteral orifice could not be seen. The roentgen diagnosis was congenital ureterocele obstructing the bladder neck, hydronephrotic right double kidney and double ureter, and possible left double kidney with nonfunctioning upper segment. The patient was discharged on April 17, 1957.

Second Admission. The patient was re-admitted on April 21, 1957. Surgery was performed by Dr. E. W. Clawater, Jr., and Dr. Fred Warren. The bladder was opened through a lower abdominal transverse incision and a left ureterocele 4 cm. in diameter was found blocking the bladder neck (Fig. 6). On the right side there was a smaller ureterocele (Fig. 7). Above each ureterocele was a second ureteral orifice. Thus, both ureteroceles were associated with the lower-terminating ureters which drained, in the usual manner, the upper segments of duplicated kidneys. A catheter was sutured in the large left ureterocele, gelatinous material aspirated, and a culture taken (later reported as *E. coli*). Retrograde pyelography (Fig. 8) now revealed tremendous dilatation of the left upper renal pelvis and its ureter, the latter measuring 1.5 cm. in diameter and being extremely tortuous. This dilated ureter was continuous with the large ureterocele which blocked the bladder outlet. The large ureterocele was resected and the ureter sutured to the skin as a ureterostomy.

Third Admission. The patient was re-admitted on June 2, 1957 for resection of the left upper kidney and ureter. This was accomplished without complication and she was discharged in good condition on June 10, 1957.

Fig. 5. Excretory urogram, same case as Figure 4. There is obvious hydronephrosis of the right duplicated kidney. The bladder defect due to the left ureterocele is strikingly demonstrated. There is opacification of the relatively normal left lower kidney, while the left upper kidney is not visualized.

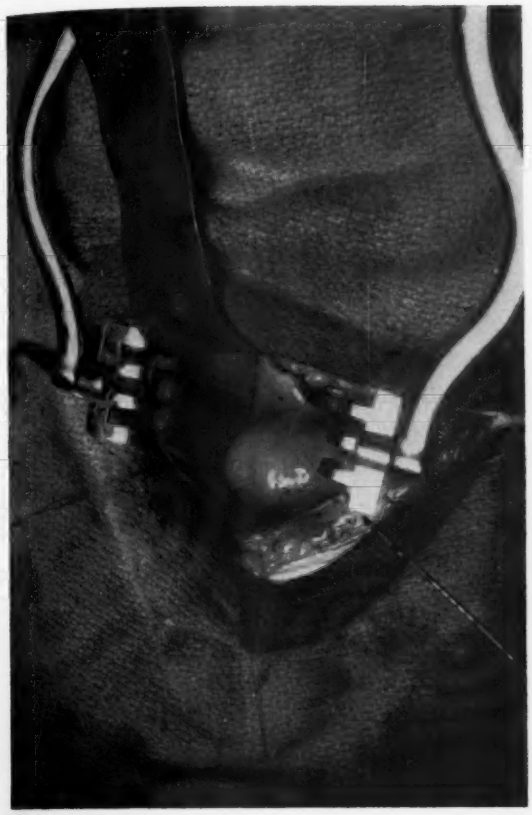


Fig. 6. Same case. Large left ureterocele as it appeared at surgery.

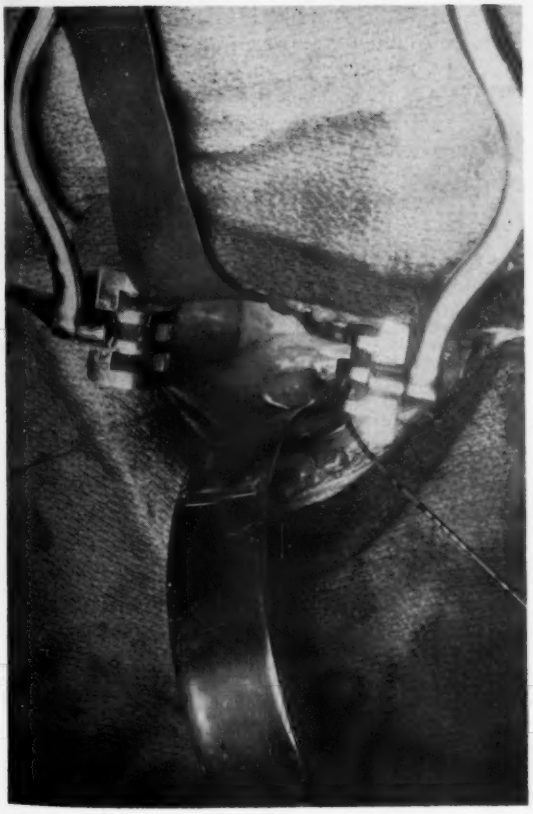


Fig. 7. Same case. Small right ureterocele as it appeared at surgery.

Fig. 8. Same case. Retrograde pyelography performed during surgery. A catheter extends up through the duplicated left ureter to the normal lower renal segment. The tremendously dilated and tortuous ureter draining the nonfunctioning upper kidney was demonstrated by sewing a catheter into the large ureterocele and injecting skiodan.

DISCUSSION

The reported case emphasizes the importance of investigating thoroughly all patients with persistent pyuria. If the cause is found early and corrected, the subsequent irreversible renal damage can usually be averted. In infants and small children, even minor urinary tract disturbances that persist should be thoroughly investigated, since renal destruction may already have occurred by the time pyuria is detected. In the patient reported, had urologic study been postponed indefinitely while various antibiotics were tried in a series of futile attempts to find the "right one," both kidneys would have eventually been destroyed by progressive back pressure, dilatation, and infection of the remaining urinary tracts.

The present instance of a ureterocele large enough to resemble a Foley catheter bag emphasizes the need of radiologists to familiarize themselves with the various manifestations of ureterocele. Quite often, the radiologist sees the patient before urologic consultation is sought, and if the proper roentgen diagnosis is made or even suspected, the patient can be referred promptly for definitive urologic treatment. This may very well constitute a life-saving procedure.

SUMMARY

1. Ureterocele is a cystic dilatation of the intramural ureter resulting from congenital stenosis of the orifice and weakness of the intramural ureteral wall.

2. The diagnosis can be made in a high percentage of cases by excretory urography, which shows a cobra head termination of the lower ureter and a surrounding halo separating it from the opacified bladder. It can be confirmed by cystoscopy.

3. If not corrected early, especially in infants and young children, ureterocele may eventually cause renal destruction.

4. Additional anomalies of the urinary tract are often found.

5. An eighteen month old infant female is reported in whom a ureterocele appeared as a radiolucent defect in the bladder base resembling a Foley catheter bag, with pyonephrosis and destruction of the corresponding renal segment. There was also a duplication of both kidneys and ureters, with a second smaller ureterocele in one of the right ureters.

1020 Clinic Drive
Tyler, Texas

The author wishes to thank Dr. Fred Warren and Dr. Earl W. Clawater, Jr., for permission to use their clinical data in this case report.

REFERENCES

1. Campbell, M. Ureterocele; study of 94 instances in 80 infants and children. *Surg., Gynec. & Obst.*, 1951, *93*, 705–718.
2. Campbell, M. Clinical Pediatric Urology. W. B. Saunders Company, Philadelphia, 1951.
3. Chwalle, R. Process of formation of cystic dilatations of vesical end of ureter and of diverticula at ureteral ostium. *Urol. & Cutan. Rev.*, 1927, *31*, 499–504.
4. Emmett, J. L., and Logan, G. B. Ureterocele with prolapse through urethra. *J. Urol.*, 1944, *51*, 19–23.
5. Gross, R. E., and Clatworthy, H. W., Jr. Ureterocele in infancy and childhood. *Pediatrics*, 1950, *5*, 68–77.
6. Herrick, F. C. Large ureterocele with herniation through urethra. *J. Urol.*, 1936, *35*, 643–645.
7. Lazarus, J. A. Cystic dilatation of lower end of ureter: Special reference to transurethral treatment with high frequency cutting current; report of two cases. *J. Urol.*, 1936, *36*, 139–149.
8. Lowsley, O. S., and Kirwin, T. J. Clinical Urology. Williams & Wilkins Company, Baltimore, 1956.
9. Rolnick, H. C. The Practice of Urology. J. B. Lippincott Company, Philadelphia, 1949.
10. Rhodes, J. S. Clinical importance of ureterocele. *J. Urol.*, 1936, *35*, 300–308.
11. Rudhe, U. Typical roentgen picture of very large ureteroceles. *Acta radiol.*, 1948, *29*, 396–402.
12. Sauer, H. R. Case of ureterocele with stone formation in ureter, ureterocele and bladder. *J. Urol.*, 1945, *54*, 158–161.

Vol. 80, No. 4

A SAFE CONTRAST MEDIUM FOR URETHROGRAPHY*

By IAN M. THOMPSON, M.D.†
ANN ARBOR, MICHIGAN

IN VIEW of many past frustrations in the attempts to achieve routinely satisfactory urethrograms, it was with interest that a study of the safety and efficacy of a new contrast medium, thickened sodium acetrizoate (trademark, Thixokon) was begun.

Urethrography has long been fraught with severe morbid effects following the use of oily media, and even with the employment of a mixture of water-soluble lubricating jelly and a contrast medium, many roentgenographic studies have been of little value, due either to lack of uniform medium dispersion, or to unsatisfactory viscosity and adherence of the vehicle.

A rather significant mortality has been seen to occur from the use of oily media introduced into the urethra under pressure, and personal, unfortunate experiences have been amply corroborated in the literature. We have subsequently been insistent in prohibiting the injection of oil into the urethra, and believe that the danger of oil embolus must constantly be reemphasized. In addition to the dangers inherent in the use of an oily suspension, many of the compounds employed since Cunningham's[1] first experiences with 50 per cent argyrol in 1910 have been found to be quite toxic when absorbed. Yet in reviewing the literature, it is obvious that the majority of the accidents which have accompanied urethrography have resulted from the utilization of oily media. An ideal material for urethrography should consist of a contrast medium of adequate radiodensity, nontoxic even for intravenous use, mixed homogeneously with a water-soluble vehicle. The type of pathologic process for which urethrography is most desirable frequently is one wherein the vascular bed is exceedingly vulnerable and accessible. Disruption of continuity of the urethra either by disease or trauma will allow vascular ingress of any substance introduced into the urethra under pressure.

We have previously noted an apparent lack of morbidity subsequent to the utilization of hand-mixed radiopaque material and water-soluble lubricating agents, and thus with the advent of thixokon, many advantages seemed theoretically possible should the medium have a satisfactory radiodensity and homogeneity of dispersion. Since the manufacturer's laboratory studies revealed that intravenous and intraperitoneal injection of thixokon in rats had produced no ascertainable deleterious effects, we began employing it in alternate cases requiring urethrography. From the inception of the study, approximately 200 urethrograms have been made with thixokon in a variety of diseases. We have noted no untoward systemic or local effects irrespective of the type of pathologic process present in the urethra, prostate, or bladder. As can be seen from the accompanying illustrations (Fig. 1–8), satisfactory urethrograms can routinely be achieved without the frustrating experience of skip areas in the density of the medium employed.

Admittedly, urethrography has a limited place in the urologic armamentarium; yet, in many instances, a clear-cut diagnostic need for the method exists, and deprecation of its potentialities derives from a haphazard performance of the procedure.

Urethrography should be more routinely employed in children, in view of the understandably small size of the instruments which must be utilized for urethrocystoscopy. It is generally agreed that urethroscopic visualization of fistulas, strictures, valves, diverticula and other types of pa-

* From the Department of Urology, University of Texas Medical Branch, Galveston, Texas.
† Present address: The University Hospital, Ann Arbor, Michigan.

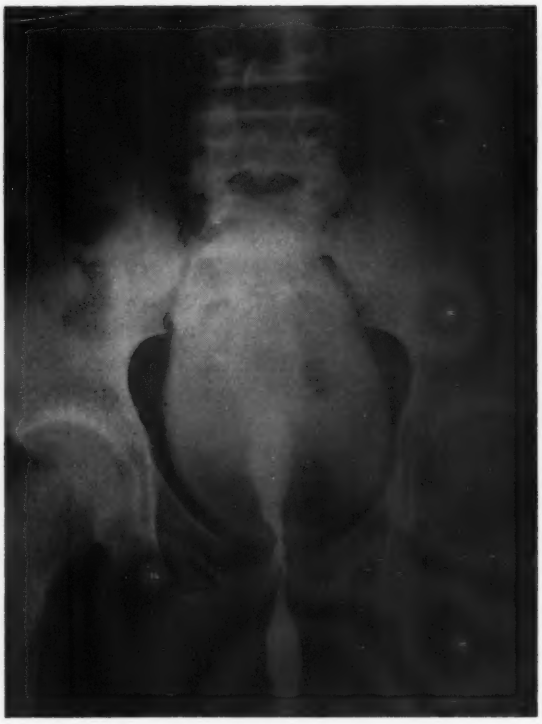


Fig. 1. Double density technique. Thixokon, more radiopaque than sodium iodide, outlines normal posterior urethral topography.

Fig. 2. Urethrogram demonstrating a urethroperineal fistula following postperineal prostatectomy.

Fig. 3. Scrotal dispersion of thixokon subsequent to traumatic urinary extravasation.

thology is often unsatisfactory and urethrography can be of great assistance.

In the case of imperforate anus in the newborn male, the presence of a urethrorectal fistula may be detected only by urethrography and only if the urethrogram

Fig. 4. Urethrogram demonstrates clearly an elongated bulbous urethral stricture as well as normal posterior urethral topography.

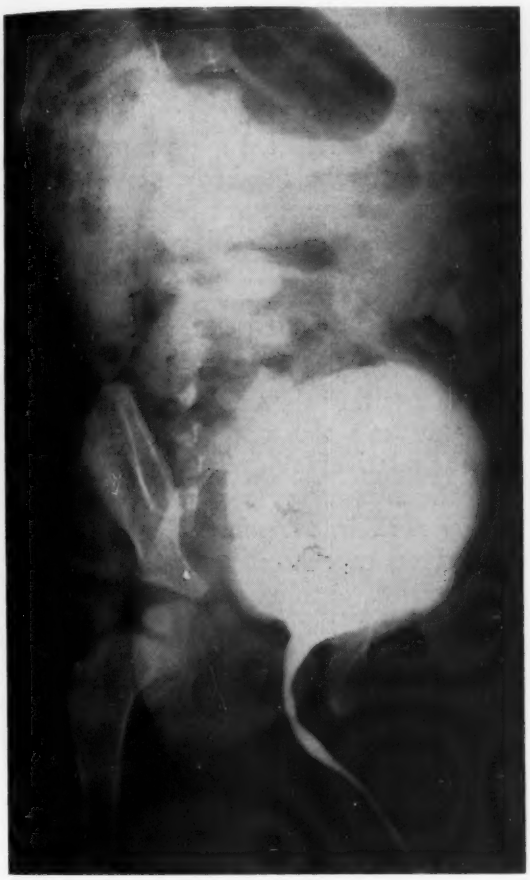


FIG. 5. Urethrogram demonstrates the absence of normal posterior urethral demarcations in a case after repair of a urethrorectal fistula (imperforate anus).

FIG. 6. Urethrogram of another case in which normal posterior urethral demarcations are absent after repair of a urethrorectal fistula.

is satisfactory in respect to radiodensity and penetration of the material. We have found thixokon to be ideal for the delineation of even minute fistulas.

Quite recently, the operation of Johanson[2] has occasioned a re-examination of the virtues of reconstructive procedures in the treatment of severe urethral strictures. In the evaluation of severe or multiple urethral strictures, urethroscopy is frequently of little value owing to the diminutive size of the urethra at the site of the stricture and the inadequacy of existing lens systems to outline the essential topographic features of the area under consideration. A urethro-

FIG. 7. Urethrogram demonstrates the outlined fistulous tract.

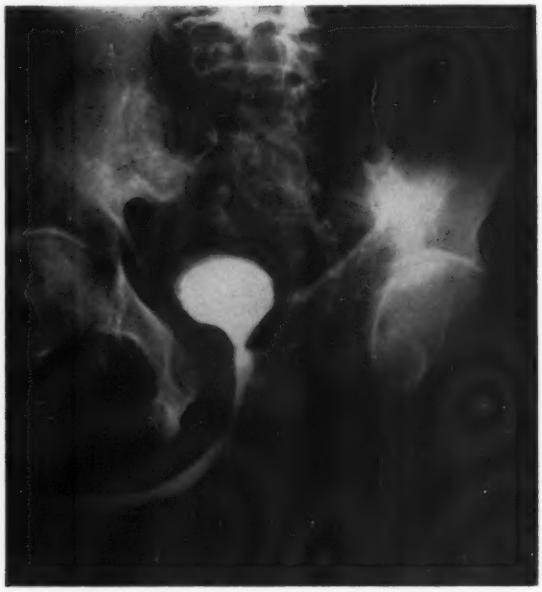


Fig. 8. Urethrogram demonstrates prostatic urethral extravasation following transurethral resection.

gram may be of great assistance in demonstrating the site and extent of the lesion and in planning the plastic reconstruction. In our most severe and heavily infected strictures, we have seen no deleterious effects whatsoever subsequent to the injection under pressure of thixokon even with definite roentgenographic evidence of extravasation locally or into the vascular bed.

In the topographic investigation of the posterior urethra for a variety of obstructive conditions, ranging from vesical neck contractures in children to prostatic enlargements in the elderly, thixokon has been of value in more precisely delineating them.

In the neurogenic bladder, functional investigation of the bladder neck and external urethral sphincteric areas has been greatly facilitated with thixokon, owing to the uniform density and viscosity of the preparation. Urethral diverticula have been more easily discovered and better outlined with thixokon than with other preparations used in the past.

Conditions for which urethrography is suitable and desirable are manifold and include in the female such problems as the detection of ectopic ureteral orifices and/or para-urethral sinuses and ducts.

In the investigation of the intersex problem, thixokon is obviously suitable owing to its safety and exceedingly high radiodensity, and it is urged that all cases of hypospadias be subjected to urethrography to rule out occasional masked cases of intersex.

Several measures have been found helpful in obtaining more diagnostic urethrograms. In the depiction of a pathologic process proximal to the external urethral sphincter, we first fill the bladder with a $2\frac{1}{2}$ per cent solution of sodium iodide and thus in securing the urethrogram, the contrast between the more opaque thixokon and the relatively dilute sodium iodide outlines the area of the posterior urethra and vesical neck in a double density fashion. Vesical resistance to the ingress of thixokon causes more optimal urethral filling and prevents the random dispersion of the urethrographic medium, producing a better visualization of the site under investigation. The placing of a finger in the rectum or deep perineum for purposes of urethral compression can be of assistance and it frequently permits a more accurate delineation of pathology and more complete filling of such entities as diverticula and fistulas.

We have found that in the male a blunt nose syringe of the asepto type is quite satisfactory for the injection of thixokon, whereas in the female an ordinary plunger syringe with a metal tip is more useful since the hub of the barrel will prevent escape of the medium from the meatus.

CONCLUSION

Urethrography should continue to occupy an important place in the urologic diagnostic armamentarium, and, in view of the efficacy and safety of such media as thixokon, a more widespread use should follow.

The University Hospital
Ann Arbor, Michigan

REFERENCES

1. Cunningham, J. H. Roentgen rays. *Tr. Am. A. Genito-Urin. Surgeons*, 1910, 369–371.
2. Johanson, B. Reconstruction of male urethra in strictures. *Acta chir. Scandinav.*, 1953, Suppl. 176.

VOL. 80, NO. 4

THIXOKON CYSTOURETHROGRAHY*

By JAMES F. GLENN, M.D.
DURHAM, NORTH CAROLINA

CYSTOURETHROGRAPHY has proved a valuable diagnostic aid to urologists and radiologists in disorders of the lower urinary tract. Since the introduction of contrast media for use in cystourethrography by Cunningham[4] in 1910, the media and techniques employed have been modified greatly. It is the purpose of this paper to discuss a new contrast medium (thixokon†) used successfully in this clinic for cystourethrography, to indicate its practical application, and to set forth the technique employed.

The value of demonstrating lower urinary tract lesions by means of cystourethrography cannot be denied. However, a number of hazards and disadvantages have been encountered with the agents currently employed. Various solutions and suspensions of radiopaque material have been advocated from time to time, including silver and its salts, barium, bismuth, thorium, and a wide variety of the iodine compounds.[1,2,5,7] Kaufman and Russell[6] have stated that the ideal cystourethrographic medium should be (1) adequately radiopaque, (2) readily sterilizable, (3) inexpensive, (4) nonirritating to urinary mucosa, (5) miscible with urine and water, (6) sufficiently viscous to outline the lower urinary tract in detail, and (7) essentially harmless if introduced into the circulatory system by accident. Many of the agents recommended in the past have possessed one or more of the desired criteria but have not proved satisfactory in all respects. The disadvantages of lipiodol and similar oily media are well known, and 27 cases of accidental introduction of oily substances into the circulation were reported by Crabtree[3] in 1947. Among these were 4 fatalities due to fat emboli. It is axiomatic that no oily substance can be injected into any part of the body without hazard. On the other hand, the water-soluble agents in current use do not possess adequate viscosity in many instances.

PROPERTIES OF THIXOKON

Over the past year, a new cystourethrographic medium, thixokon, has been employed in this clinic. It has been found to satisfy all of the established criteria for cystourethrographic agents. Thixokon is a thickened solution of sodium acetrizoate (urokon sodium) with an iodine content of 32.9 per cent in the resulting mixture. The thickening agent is amioca, a thixotropic non-jelling starch consisting of nearly 100 per cent amylopectin. The thixotropic property of this new contrast agent engenders a variable viscosity depending upon state of motion and allows ready introduction of the agent combined with desired retention of the medium once it comes to rest. The resulting mixture is entirely water soluble, possesses a high degree of radiopacity, and is simple to use. In experimental study by the manufacturer,[8] thixokon has been found nontoxic in laboratory animals when injected intravenously and intraperitoneally.

PRACTICAL APPLICATION

Thixokon cystourethrography has been employed in over 60 patients in this clinic with a wide variety of pathologic conditions of the lower urinary tract. It has proved diagnostically satisfactory in all cases. Thixokon cystourethrography is especially valuable in the diagnosis of urethral strictures, urethral fistulae, urethral diverticula, bladder diverticula, trauma and perforations of the bladder and urethra, congenital

† Thixokon, brand of thickened sodium acetrizoate, used in this study was supplied by the manufacturers, Mallinckrodt Chemical Works, St. Louis, Missouri.

* From the Department of Surgery, Urologic Division, Duke Hospital and Duke University School of Medicine, Durham, North Carolina.

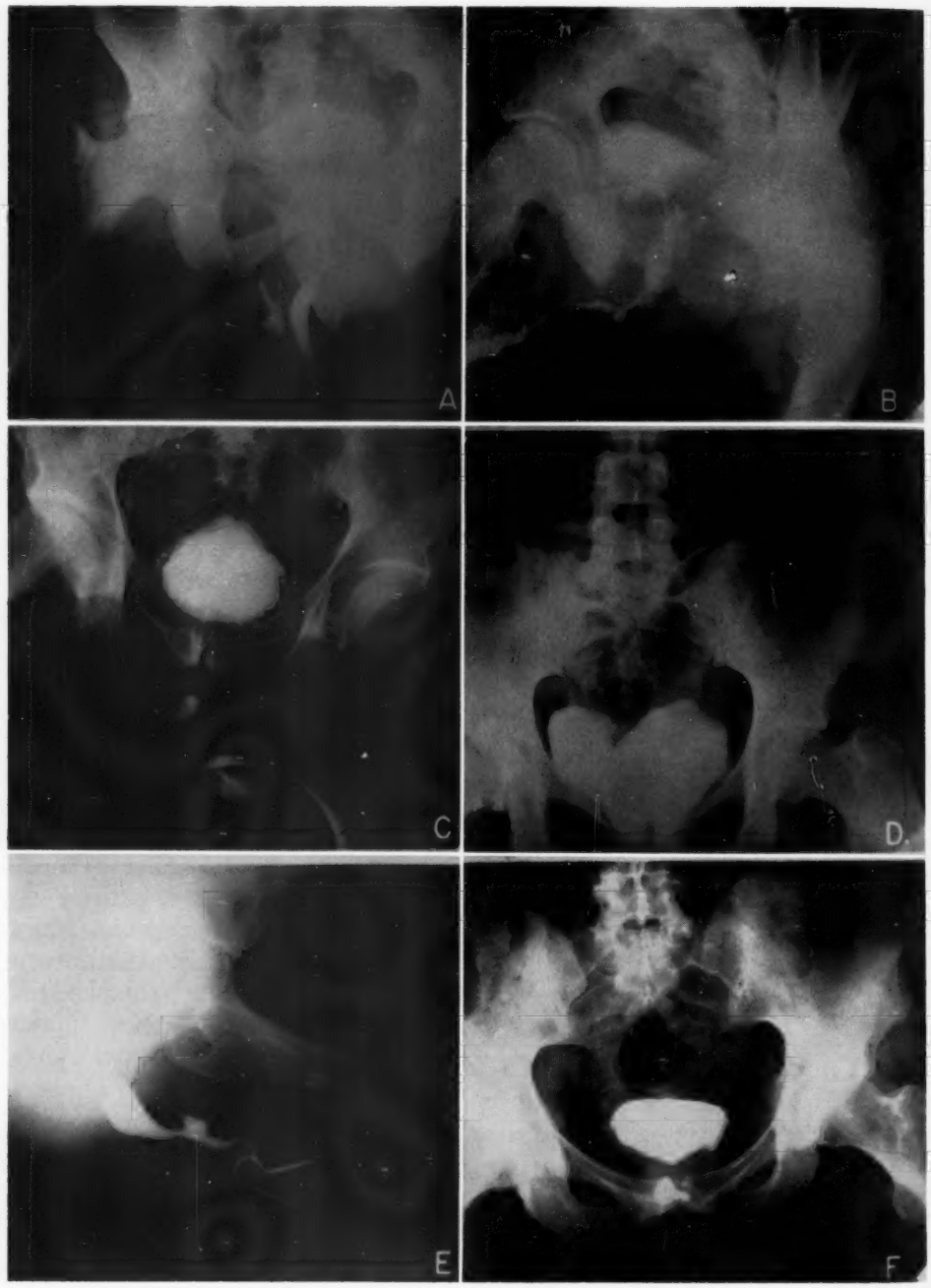


Fig. 1. Thioxokon cystourethrograms. (*A*) Anteroposterior view of a male with multiple urethral strictures and fistulae. (*B*) Same patient, oblique view, showing better visualization. (*C*) Voiding cystourethrogram, carcinoma of the prostate, showing narrowed prostatic urethra and multiple cellules of bladder. (*D*) Cystovaginogram in femal pseudohermaphrodite, with transverse bladder shadow superimposed over distended vagina, injected via urogenital sinus. (*E*) Stricture of penile urethra and urethral diverticulum. (*F*) Thixokon remaining in large diverticulum of female urethra several minutes after injection.

anomalies of the lower urinary tract, benign prostatic hypertrophy with intravesical protrusion, and carcinoma of the prostate. This agent might also be employed in the diagnosis of urethral tumors, prostatic reflux, and bladder tumors; and it has further been suggested that thixokon might be useful in fistulography elsewhere in the body. Examples of thixokon cystourethrography are shown in Figure 1.

TECHNIQUE

The technique of cystourethrography employed with thixokon is comparable to that used with other agents and in other clinics. Thixokon may be employed in its prepared state, or it may be thinned by the addition of sterile water as desired. It has been found that mixtures of up to two parts sterile water to one part thixokon retain a high degree of radiopacity, and that the thixotropic property of the agent is not markedly diminished by such dilution.

If it is desirable to obtain a cystogram, the patient is asked to retain urine over a two to three hour period, in order that dilution of the introduced medium may adequately outline the distended bladder. Thixokon is introduced into the urethra utilizing a 15 cc. or 30 cc. asepto bulb syringe, either blunt nosed or standard variety, but might also be introduced by ordinary intravenous syringe with urethral adapter. In the male, one of the various penile clamps should be employed to protect the operator's hand from roentgen-ray exposure. The blunt-nosed syringe proves most satisfactory in the female.

The patient is centered over an 11 by 14 inch film, and employing the usual sterile technique, approximately 15 to 20 cc. of thixokon is injected slowly into the urethra, avoiding undue pressure. During the terminal portion of this injection the initial roentgenogram may be made, but it is possible to expose the film after the operator has left the room, since the thixotropic property allows retention of the agent in the urethra, in contrast to many other agents. We feel this to be a definite advantage, eliminating the hazards of exposure to irradiation. A subsequent oblique roentgenogram is frequently helpful, and this is accomplished by re-positioning the patient and injecting an additional 15 to 20 cc. of thixokon. Frequently these two roentgenograms will prove diagnostic.

However, it has been pointed out that voiding cystourethrograms are often of value,[6] and these may be readily obtained. In the male, a disposable plastic bag may be attached to the penis or the patient may be asked to void into a basin, and the film is exposed during the act of voiding with the patient in either the anteroposterior or the oblique position. This technique will frequently outline an unsuspected dilatation or sacculation of the urethra, or may more graphically demonstrate the existing pathology.

In this clinic, the roentgenographic technique employed consists of 25 ma. seconds (one-half second exposure at 50 ma.) and 65 to 75 kv. for the average patient.

No instances of extravasation and no untoward reactions have been encountered, but users must be cautioned against the possibility of extravasation or an allergic reaction, as with other iodine compounds injected into the body. In all instances, patients are questioned as to allergic history. Users are also cautioned that thixokon may deteriorate if exposed to daylight for prolonged periods of time, resulting in loss of radiopacity.

SUMMARY

1. Cystourethrography is a valuable aid in the diagnosis of lower urinary tract pathology.

2. A new cystourethrographic agent, thixokon, is discussed. Thixokon has been found to satisfy the criteria of an ideal cystourethrographic medium and the unique thixotropic property permits its retention within the urethra for some minutes after injection.

3. The technique of thixokon cystourethrography is presented.

4. Representative diagnostic thixokon cystourethrograms are reproduced.

School of Medicine
Duke University
Durham, North Carolina

The author wishes to express thanks to Dr. E. P. Alyea, Chief of Urology, for advice and encouragement.

REFERENCES

1. Beard, D. E., Goodyear, W. E., and Weens, H. S. Radiologic Diagnosis of the Lower Urinary Tract. Charles C Thomas, Springfield, Ill., 1952.
2. Brodny, M. L. Urethrography: Its value in study of male fertility and sterility. *Fertil. & Steril.*, 1953, *4*, 386–411.
3. Crabtree, E. G., Venous invasion due to urethrograms made with lipiodol. *J. Urol.*, 1947, *57*, 380–389.
4. Cunningham, J. H. Roentgen rays. *Tr. Am. A. Genito-Urin. Surgeons*, 1910, *4*, 369–371.
5. Flocks, R. H. Roentgen visualization of posterior urethra. *J. Urol.*, 1933, *30*, 711–736.
6. Kaufman, J. J., and Russell, M. Cystourethrography; clinical experience with newer contrast media. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1956, *75*, 884–892.
7. Richards, C. E. Visco-rayopake in cystourethrography. *J. Urol.*, 1947, *58*, 185–191.
8. Thixokon preliminary data. Mallinckrodt Chemical Works, St. Louis, May 21, 1956.

VOL. 80, NO. 4

ROENTGENOGRAPHIC MANIFESTATIONS IN A SEVERE CASE OF ALKAPTONURIC OSTEOARTHRITIS

By J. PAGAN-CARLO, M.D.,* *and* ARTHUR R. PAYZANT, M.D.†
NEW ORLEANS, LOUISIANA

ALKAPTONURIA may be defined as a disease resulting from a congenital error in the metabolism of two amino acids, tyrosine and phenylalanine. Specifically speaking, homogentisic acid, which is the intermediate product of the metabolic breakdown of tyrosine and phenylalanine, is not broken down and the acid is excreted in the urine. Sacks[6] found that about 50 per cent of the patients with alkaptonuria develop ochronosis with degenerative osteoarthritis, the onset of symptoms rarely occurring before the age of forty. Minno and Rogers,[4] describing a case, state that alkaptonuric osteoarthritis is an extremely rare disorder, but, when present, is quite disabling.

According to Sacks,[6] the relationship of association of degenerative osteoarthritis with alkaptonuria was first stressed by Gross and Allard. Hertzberg[3] describes the pathologic process in ochronotic arthritis as one of deposition of ochronotic pigment in the articular cartilages, especially in old cartilage with poor metabolism. The cartilage becomes black, loses elasticity, becomes brittle, and shows little resistance to strain, thereby cracking easily. Detached small black fragments may later become adherent to the synovial membrane. Lacunar bone absorption occurs under the devitalized or destroyed cartilage and the patient is susceptible to fractures from minor injuries. The ultimate picture is one of ankylosis of the point with proliferation of marginal osteophytes.

The roentgenographic manifestations of alkaptonuric osteoarthritis are quite characteristic, as pointed out by Hertzberg,[3] and perhaps sufficient to establish the diagnosis, which later is confirmed by the clinical and laboratory findings. Eisenberg[1] comments that there is a typical triad of symptoms or signs; namely, alkaptonuria, ochronosis, and arthritis. It appears that in the absence of ochronosis degenerative osteoarthritic changes of the severity usually associated with the disease will not develop.

Pomeranz and associates[5] report that osteoporotic changes associated with the severe form of osteoarthritis manifested in the spine, shoulders, and hips are more or less the result of disuse and not characteristic of the disease itself. They again refer to the triad of alkaptonuria, ochronosis, and arthritis. They comment that calcifications such as are found in the intervertebral cartilages and ligaments are also found in the tendon sheaths, bursal sacs, and synovial membranes. Pomeranz and his coworkers[5] point out the following salient features in the roentgen manifestations of ochronotic arthritis: in the spine there is a characteristic general calcification of practically all of the intervertebral cartilages which appear like elliptical opaque wafers; in the shoulder, the most interesting point is the unusually marked narrowing of the joint space; in the pelvis there may be narrowing of the iliosacral synchondroses with irregular flocculent calcifications in the soft tissues between the femoral and acetabular shelves; similar calcifications are noted in the tendons attached to the greater trochanters; in the knees similar calcifications may be found in the quadriceps tendon and to a lesser degree in the patellar tendons. Harrold[2] reports an interesting finding—the fact that there are definite changes in

* Jacob Aaron Fellow, Department of Radiology, Touro Infirmary, New Orleans, Louisiana.
† Chief Radiologist, Department of Radiology, Touro Infirmary, New Orleans, Louisiana.

Fig. 1. February 12, 1955.

Fig. 2. February 12, 1955.

Fig. 3. February 12, 1955.

the symphysis pubis which roentgenographically resemble those seen in postoperative osteitis pubis.

REPORT OF A CASE

The case presented is an example of alkaptonuric degenerative osteoarthritis of a very severe degree. This fifty-five year old white female had a history of progressive and incapacitating pains in the hips and knees as well as in the shoulders; onset of symptoms was at the age of forty or fifteen years prior to the first hospital admission in February, 1955. At the time of admission the patient gave a history of passing urine which upon standing became

Fig. 4. February 12, 1955.

black. This condition had been noted since birth. There was also a history of right nephrolithiasis resulting in a right nephrectomy several years prior to this admission. Laboratory work-up revealed the presence of homogentisic acid in the freshly voided urine.

Roentgenograms of the spine, shoulders, knees, pelvis, and both hips were obtained during the first hospital admission (Fig. 1–7). In

Fig. 5. February 12, 1955.

Fig. 6. May 22, 1956.

the thoracic and lumbar spine (Fig. 1–4) an ankylosing type of spondylitis was noted, with calcification of the paravertebral ligaments and intervertebral disks; there was moderate osteoporosis and narrowing of the intervertebral spaces. In the pelvis (Fig. 5), including both hip joints, there was narrowing of the hip joint space on the right with an associated sclerosis of the adjoining articular margins of the head of the femur and the acetabulum, the head of the right femur appearing slightly flattened. The left hip joint appeared essentially normal except for mild sclerosis of the upper acetabular shelf. In the shoulders changes similar to those noted in the right hip joint were seen, although not as severe. The left shoulder appeared to be more involved with calcifications in the soft tissues adjacent to the joint capsule (Fig. 6). In the knee changes characteristic of severe degenerative osteoarthritis were present

Fig. 7. February 12, 1955.

Fig. 8. December 27, 1955.

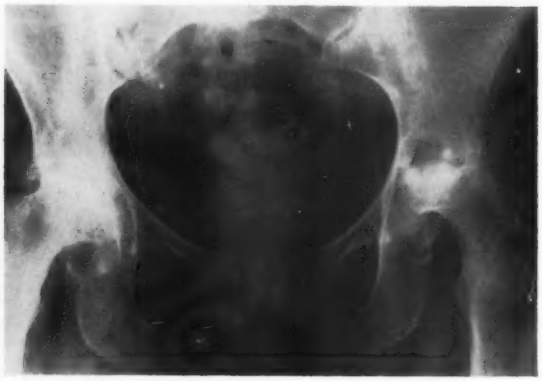


Fig. 9. May 22, 1956.

Fig. 10. December 17, 1957.

along with narrowing of the joint space, associated with marginal sclerosis and osteophytic proliferation, and mild calcium deposition in the ligamentum patellae (Fig. 7).

From the first admission until October, 1957, the patient had been admitted to the hospital four times. The marked changes with progressive destruction of the cartilaginous substance in both hip joints which occurred during that period are shown in Figures 8, 9 and 10. As previously noted the diagnosis of alkaptonuria with ochronosis and degenerative osteoarthritis had been made on the first admission.

During the physical examination a bluish discoloration of the cartilage of the ear and a brownish pigmentation of the sclerae were noted. Further inquiry into the patient's family history failed to reveal any sibling or relative with a similar condition.

SUMMARY

The roentgenographic manifestations of alkaptonuric osteoarthritis have been discussed.

Roentgenograms demonstrating the progress of this rather severe and disabling type of osteoarthritis have been presented.

J. Pagan-Carlo, M.D.
3912 Joliet Street, Apt. 20
New Orleans 18, Louisiana

We wish to acknowledge the help of Dr. Donald Bradburn, Associate Pathologist, Touro Infirmary, in the preparation of the roentgenographic reproductions.

REFERENCES

1. Eisenberg, H. Alkaptonuria, ochronosis, arthritis and ruptured intervertebral disk. *Arch. Int. Med.*, 1950, *86*, 79–86.
2. Harrold, A. J. Alkaptonuric arthritis. *J. Bone & Joint Surg.*, 1956, *38-B*, 532–538.
3. Hertzberg, J. On osteoarthrosis alkaptonurica (ochronotica) with description of one case. *Acta radiol.*, 1945, *26*, 484–490.
4. Minno, A. M., and Rogers, J. A. Ochronosis; report of case. *Ann. Int. Med.*, 1957, *46*, 179–183.
5. Pomeranz, M. M., Friedman, L. J., and Tunick, I. S. Roentgen findings in alkaptonuric ochronosis. *Radiology*, 1941, *37*, 295–303.
6. Sacks, S. Alkaptonuric arthritis; report of case. *J. Bone & Joint Surg.*, 1951, *33-B*, 407–414.

VOL. 80, NO. 4

ENLARGEMENT OF THE PLACENTA AS DEMONSTRATED BY SOFT TISSUE PLACENTOGRAPHY*

By JAMES W. RYEL, M.D., *and* GEORGE JACOBSON, M.D.
LOS ANGELES, CALIFORNIA

SOFT tissue roentgenography performed for localization of the placenta occasionally reveals a placental shadow that is definitely larger than normal. We have encountered no study devoted solely to the roentgen evaluation of the enlarged placental shadow, and only a few which have mentioned it even as an incidental finding. Snow and Powell,[11] in their original description of soft tissue placentography, documented 3 cases of placental apoplexy. Their single illustrated case showed a thickened placental shadow with a distinct bulge on the external surface of the uterus. They believed that this was a significant finding provided that uterine fibroids could be excluded. Bishop[1] presented a case in which he diagnosed premature separation of the placenta on the basis of a thickened placental shadow. At delivery, however, the placenta was found to be intact with no evidence of abruption, although the localization of the placenta was correct. He stated that at that time he was unable to give roentgenographic criteria by which the diagnosis of premature separation could be made. Qvist,[9] in reviewing his cases of soft tissue placentography, found 2 in which the question of premature separation of the placenta was raised on the basis of a thick placental shadow measuring 9 cm. in one instance and 9.5 cm. in the other. Apparently neither of these cases was confirmed.

The location of the placenta and, more particularly, the normally implanted placenta can often be demonstrated by roentgenograms in the anteroposterior and lateral views of the maternal abdomen alone since, as shown by Reid[10] in his fundamental work on soft tissue placentography, the placenta is rarely located entirely on the lateral wall of the uterus. Even so, examination in additional views, such as oblique and lateral recumbent views, is frequently necessary. The determination of the size of the placenta is more difficult, and can only be estimated roentgenographically by having the central ray pass through the point of maximum placental thickness. Since the placenta is rarely confined to one wall of the uterus, and, in addition, axial rotation of the uterus almost always occurs, neither the anteroposterior nor the lateral view can be completely relied upon to reveal the maximum placental shadow. Therefore, in the authors' judgment, oblique views are essential if the maximum thickness is to be demonstrated in every case. It is felt that the relative infrequent use of routine oblique views in placentography is partly responsible for the fact that the enlarged placental shadow has not received more attention.

TECHNIQUE

The technique used at the Los Angeles County Hospital for the past seven years consists of roentgenography of the abdomen in the anteroposterior, right posterior oblique, left posterior oblique, and left lateral views. A differential absorption filter is employed for the exposures in the oblique and lateral views. An additional lateral roentgenogram of the maternal pelvis is made with the patient recumbent, to evaluate the space between the presenting part and the promontory of the sacrum. Patients referred for placentography at this institution almost invariably give a history of bleeding, and not infrequently are actively bleeding at the time of examination. Due to the possibility of initiating serious hemorrhage, the patients are ex-

* From the Departments of Radiology, School of Medicine, University of Southern California, Los Angeles County Hospital (G.J.) and St. Jude Hospital, Fullerton, California (J.W.R.).

amined only horizontally and no roentgenograms are obtained in the upright position.

The question has been raised as to the amount of radiation received by the patient and fetus in carrying out such an examination. Our measurements indicate that the total surface radiation to the mother for the five exposures is approximately 12 r. At the exposure factors used (300 ma., 80–90 kv., 1 mm. Al plus differential filter, 40 inch tube-film distance), the depth dose at 10 cm. is about 15 per cent of the surface dose or less than 2 r. Since this amount of radiation is delivered to the enlarged pregnant abdomen, the dose to the fetus and to the maternal ovaries is less than 2 r. In view of the seriousness of the suspected diagnoses for which this examination is performed, we do not believe that this amount of radiation is excessive. The fetal mortality in placenta previa is approximately 50 per cent and is even higher in some of the conditions to be discussed.

NORMAL PLACENTA

The comparative weight of the normal placenta and fetus varies considerably depending on the period of gestation. In the early stages of pregnancy, the weight of the placenta far exceeds that of the fetus. At the fourth month of gestation, the fetal and placental masses are almost equal, while at term the fetus weighs approximately seven times as much as the placenta. It has been stated by Reid[10] and others that the average placenta at term weighs about 500 gm. and casts a shadow up to 7 cm. in thickness. It should be noted that this includes the uterine wall. Our experience with oblique views, however, indicates that this measurement is probably too small and we have found that the normal placenta not infrequently measures as much as 9 cm. in thickness.

The accuracy of both the determination of placental size and placental localization increases with the period of gestation. The fetus conforms most closely to the uterine cavity at term. The earlier the stage of pregnancy, the greater is the discrepancy in size between the two. We have found that prior to term, particularly in the second trimester, evaluation of placental size may be exceedingly difficult. Certain variations of presentation, such as breech or transverse lie, also make evaluation of placental size uncertain. It is apparent that many of the pitfalls encountered in localizing the placenta apply equally to judging its size. Consequently the diagnosis of an enlarged placenta is reserved for those instances in which the findings are unequivocal.

ENLARGEMENT OF THE PLACENTAL SHADOW

In studying the enlarged placental shadow, the cases may be divided into two groups: (1) those cases in which there is a true volumetric increase in the placental mass, (2) those cases which simulate placental enlargement.

1. True enlargement of the placental shadow is the result of: (a) erythroblastosis (hydrops fetalis); (b) premature separation of the normally implanted placenta; (c) syphilis; (d) diabetes; (e) placental tumors; and (f) continued growth of the placenta after fetal death.

2. Pseudo-enlargement of the placental shadow is the result of: (a) polyhydramnios; (b) abnormal presentation of the fetus; (c) tumors or abnormalities of the uterus; (d) abnormalities of the fetus; and (e) prematurity (relative polyhydramnios).

1. TRUE ENLARGEMENT OF THE PLACENTAL SHADOW

(a) *Erythroblastosis.* This condition is due to transplacental passage of an anti-Rh agglutinin produced in an Rh negative mother who has been immunized by Rh positive red blood cells from the fetus or by a previous transfusion of Rh positive blood. It results in excessive destruction of red blood cells and compensatory overdevelopment of erythropoietic tissue. It has been variously reported as occurring once in every 150 to 500 deliveries.[3,4,5] Three clinical varieties of the disease are recognized: anemia of the newborn, icterus gra-

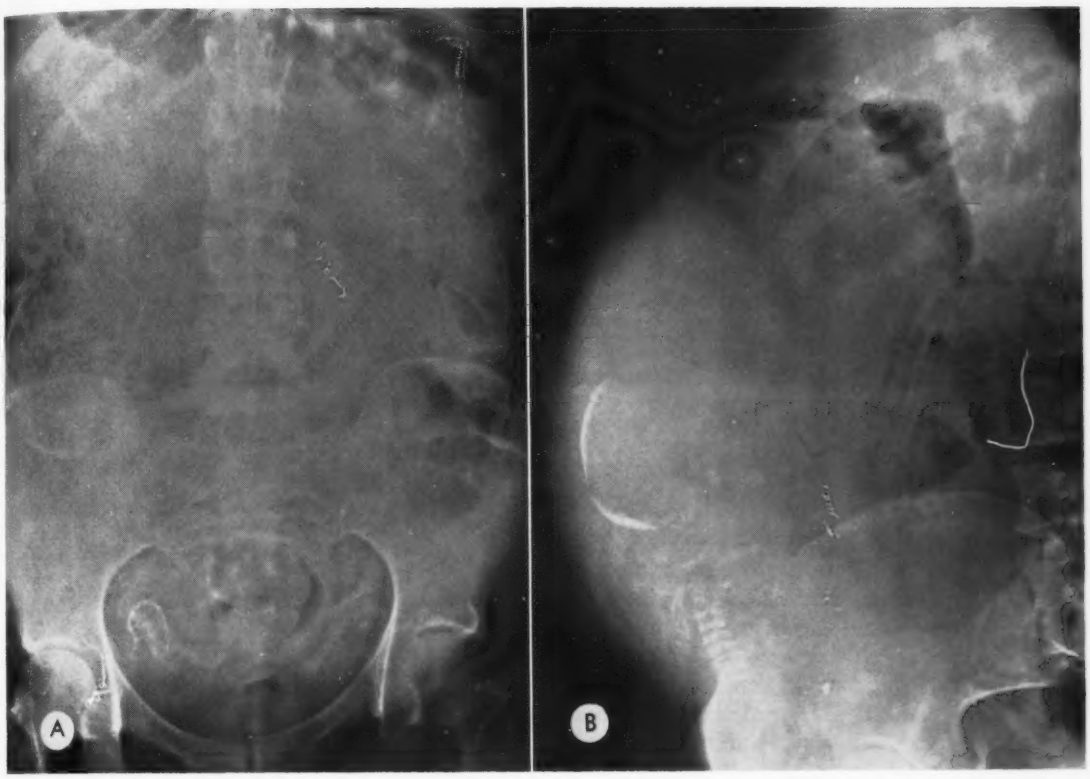


Fig. 1. Case 1. (*A* and *B*) Erythroblastosis. The placenta is located posterolaterally in the fundus and has a thickness of 15 cm. The fetus is displaced anteriorly, inferiorly and to the right. Note the compressed appearance of the fetus (*B*). At delivery the placenta was very large and unusually friable with no evidence of premature separation.

vis neonatorum and hydrops fetalis. The enlargement of the placenta is due to edema and can occur with either a normal or edematous fetus. Hydrops fetalis, the severest and rarest form of the disease, is almost invariably accompanied by edema of the placenta which, under these circumstances, may be extremely large and exceed one-half the weight of the fetus.

Case 1. T.J.F., twenty-five year old Caucasian female; gravida II, para I; last normal menstrual period September 18, 1952; expected date of delivery June 25, 1953.

Present illness. The patient entered the hospital on March 10, 1953 with a history of an uneventful pregnancy until approximately two months prior to entry, when mild pre-eclamptic toxemia symptoms were noted.

Physical examination. The patient was quiet and in no apparent distress. The blood pressure was 154/84. The uterus was soft, nontender, and no contractions were noted. No fetal heart tones were heard. The height of the fundus was 20 cm.

Laboratory findings. Minimal albuminuria was present. The blood was Rh negative. The blood fibrinogen level was .575 gm. per cent (normal .25 gm. per cent to .35 gm. per cent).

Placentographic findings (Fig. 1). Soft tissue placentography showed a single fetus of approximately six months' gestation in a breech presentation. The placenta was located posterolaterally in the fundus and its maximum thickness was 15 cm. The fetus was displaced anteriorly, inferiorly, and to the right, and had a compressed appearance.

Course. Toxic symptoms persisted and labor was induced. A stillborn, slightly edematous fetus was delivered on March 19, 1953. The placenta was very large, unusually friable and showed no evidence of premature separation. It measured 22 cm. in diameter and was badly macerated. The final diagnosis was erythroblastosis and mild pre-eclampsia.

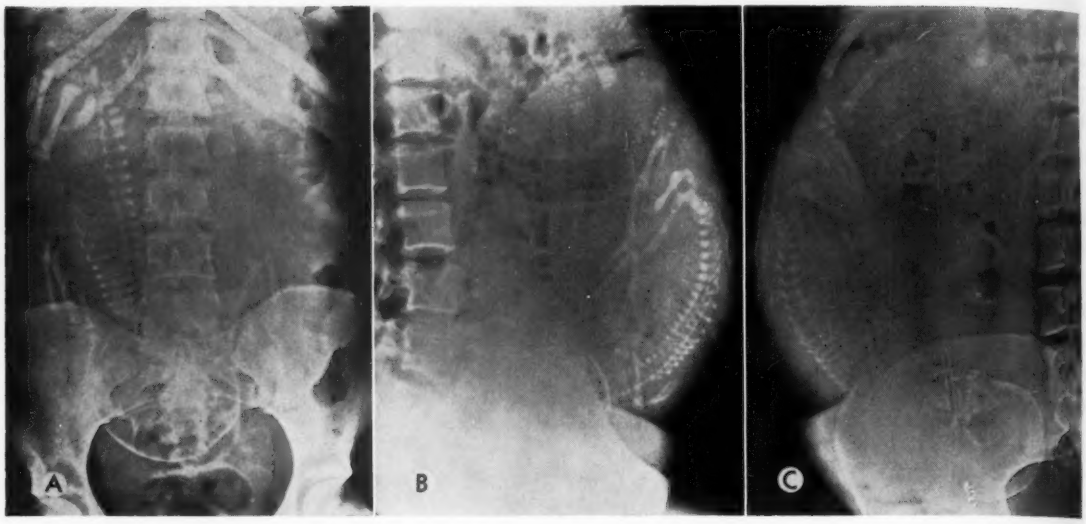


FIG. 2. Case II. (*A*, *B* and *C*) Erythroblastosis. The placenta is located posteriorly. It measures 11 cm. in the lateral view (*B*), and 16 cm. in the oblique view (*C*). The fetus is displaced anteriorly. Note the compressed appearance of the fetus in the oblique and lateral views. At delivery the placenta was enlarged and weighed 1,150 gm.

CASE II. M.A., twenty-seven year old Mexican female; gravida VII, para VI; last normal menstrual period August 1, 1951; expected date of delivery May 8, 1952.

Present illness. The patient entered the hospital on March 26, 1952 with a history of an uneventful pregnancy until four days prior to entry when fetal movements ceased. Twenty-four hours prior to entry uterine contractions were noted. This was accompanied by brisk vaginal bleeding which rapidly diminished to a slight brownish discharge at the time of entry.

Past history. The patient was known to be Rh negative and her husband was Rh positive. Her first pregnancy resulted in a 3 pound infant that lived and is now normal. Five subsequent pregnancies resulted in living infants who died shortly after delivery.

Physical examination. The uterus was soft, nontender, and no contractions were present. No fetal heart tones could be heard.

Laboratory findings. The blood was Rh negative and a maternal Rh titer of 1 to 32 was reported. The type of titer was not stated.

Placentographic findings (Fig. 2). Soft tissue placentography showed a single fetus of approximately seven and one-half to eight months' gestation in cephalic presentation. The placenta was located posteriorly and measured a maximum 16 cm. in the oblique view and 11 cm. in the lateral view. The fetus was displaced anteriorly. There was a compressed appearance of the fetus in the oblique and lateral views.

Course. A stillborn fetus weighing 3 pounds, 2 ounces was delivered on March 27, 1952. The placenta was located above the equator of the uterus on the posterior wall and had to be removed manually. It was unusually large and weighed 1,150 gm. The pathologist (Weldon K. Bullock, M.D.) reported that the histologic characteristics of the placenta were not conclusive for erythroblastosis. The autopsy of the stillborn fetus revealed a grossly edematous macerated male infant. No gross congenital abnormalities were noted. Microscopically, the majority of the organs were autolyzed but the lungs did show primitive normoblasts within the lung capillaries. The anatomic diagnoses were (1) stillborn, (2) hydrops fetalis (erythroblastosis).

Comment. The marked enlargement of the placenta is readily discernible in both of these cases and in each there is the characteristic eccentric location and compressed appearance of the fetus. Case II also illustrates the value of the oblique view in demonstrating the maximum thickness of the placenta.

The clinical diagnosis in Case I was in doubt and the patient's symptoms were attributed entirely to pre-eclampsia. In

view of this the roentgenographic findings were interpreted as being indicative of premature separation of the placenta with retroplacental bleeding. At delivery, however, there was no evidence of a premature separation, and it was evident that the enlargement of the placenta was due to a coexistent erythroblastosis.

Since the patient had had five previous pregnancies complicated by erythroblastosis, there was no doubt as to the diagnosis in Case II. It should be noted that the placenta weighed almost as much as the fetus.

(b) *Premature Separation of the Normally Implanted Placenta.** Premature separation of the placenta has various synonyms including abruptio and ablatic placenta, and placental apoplexy. The term "Couvelaire uterus" is reserved for those cases in which there is hemorrhage into the interstices of the uterus. The etiology is unknown although the condition is more common in pre-eclamptic toxemia. Beck states that a marked degree of separation occurs once in each 200 deliveries. When the separation involves the central portion of the placenta, a retroplacental hematoma results which may compress the chorionic villi and not infrequently embarrasses the fetal circulation. In these cases, the appearance of the maternal surface often resembles an infarct. When marginal separation occurs, most of the bleeding is into the uterine cavity and a retroplacental hematoma may or may not be produced.

The classic syndrome of pain associated with a tense, hard uterus and shock may be absent and often the patient's only complaint is painless bleeding.

Case III. A.R., nineteen year old Negro female; gravida II, para I; last normal menstrual period September 12, 1951; expected date of delivery June 19, 1952.

Present illness. The patient entered the hospital on February 12, 1952, complaining of vaginal spotting and lower abdominal cramps of two weeks' duration.

Past history. One previous pregnancy, two years prior to entry, resulted in a normal male infant weighing 7 pounds, 13 ounces.

Physical examination. The uterus was soft, nontender, and no contractions were present. The height of the fundus was 20 cm. and the fetal heart tones were good.

Laboratory findings. The blood was Rh positive and the hemoglobin was 11 gm.

Placentographic findings (Fig. 3). Soft tissue placentography showed a single fetus of approximately five to six months' gestation in cephalic presentation. The placenta occupied the fundus of the uterus and, in the oblique views, had a maximum thickness of 15 cm. The fetus was displaced inferiorly into the maternal pelvis and had a compressed appearance.

Course. The patient continued to have minimal bleeding and during the next two weeks the hemoglobin dropped from 11 to 6 gm. There was no clinical evidence of a sudden hemorrhage during this period. On February 29, 1952 a stillborn male infant was delivered. A 400 cc. blood clot completely covered the maternal surface of the placenta. The fetus was not macerated.

Case IV. F. L., thirty-two year old Caucasian female; gravida IV, para III; last normal menstrual period July 19, 1956; expected date of delivery April 20, 1957.

Present illness. Pregnancy was uneventful until one month prior to entry when painless vaginal bleeding began, requiring about three pads a day. The patient entered the hospital on January 7, 1957 after more severe bleeding which resulted in an estimated loss of 1 pint of blood. This latter episode was associated with intermittent low abdominal and back pain.

Past history. A pregnancy in 1943 was uneventful. A cesarean section was performed at term in 1945 because of placenta previa.

Physical examination. The uterus was tense, hard, and there was minimal tenderness over the lower uterine segment. No fetal heart tones were heard.

Laboratory findings. The blood was Rh negative. The laboratory findings were otherwise not remarkable.

Placentographic findings (Fig. 4). Soft tissue placentography showed a single fetus of approximately six months' gestation in a breech presentation. The placenta was located in the fundus posteriorly and had a maximum thick-

* Premature separation of the placenta is classified as a true enlargement of the placenta since the retroplacental hematoma adds to the total placental mass.

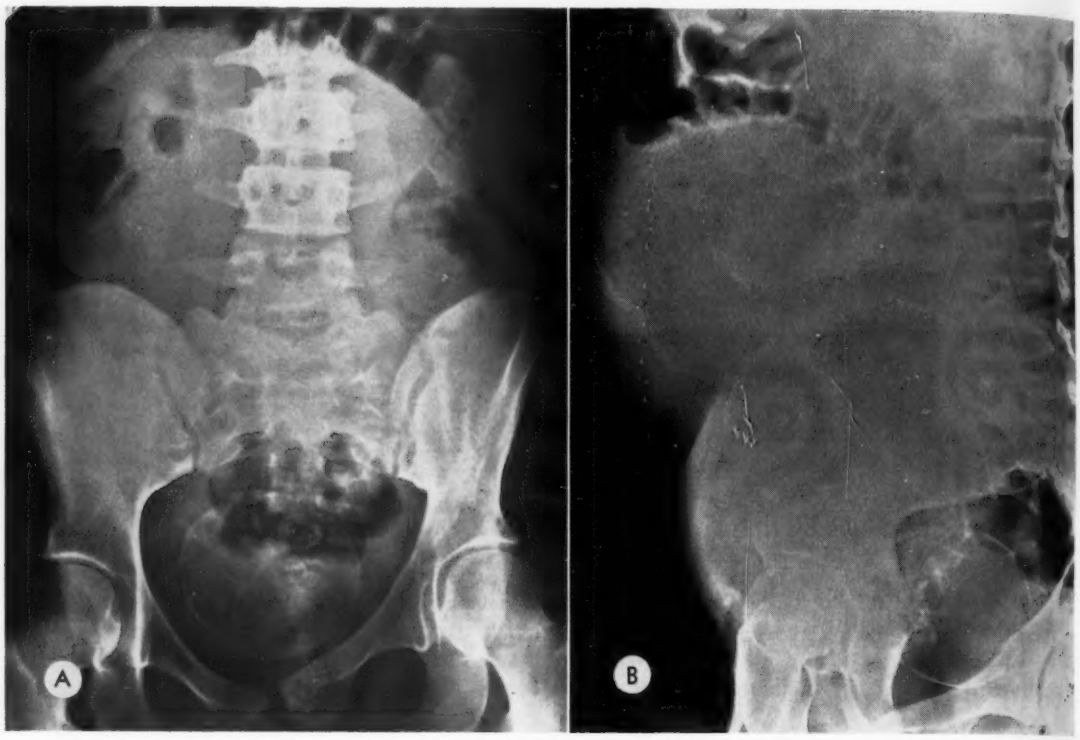


Fig. 3. Case III. (*A* and *B*) Premature separation of the placenta. The placenta occupies the fundus and has a maximum thickness of 15 cm. in the oblique view (*B*). The fetus is displaced inferiorly and has a compressed appearance. A 400 cc. retroplacental hematoma was found at delivery.

ness of 11 cm. The fetus was displaced anteriorly and presented a compressed appearance.

Course. Spontaneous delivery occurred on January 8, 1957 after an uneventful labor, and resulted in a stillborn infant. An 800 cc. hematoma was found on the maternal surface of the placenta.

Case v. F.L., twenty-two year old Caucasian female; gravida IV, para III; last normal menstrual period July 28, 1953; expected date of delivery May 5, 1954.

Present illness. The patient was admitted on March 22, 1954 with a history of an uneventful pregnancy until the day of admission. She complained of having had a sudden mild constant suprapubic pain which had lasted one

Fig. 4. Case IV. Premature separation of the placenta. The placenta is located posteriorly and has a maximum thickness of 11 cm. The fetus is displaced anteriorly and inferiorly and has a compressed appearance. A retroplacental hematoma of 800 cc. was found at delivery.

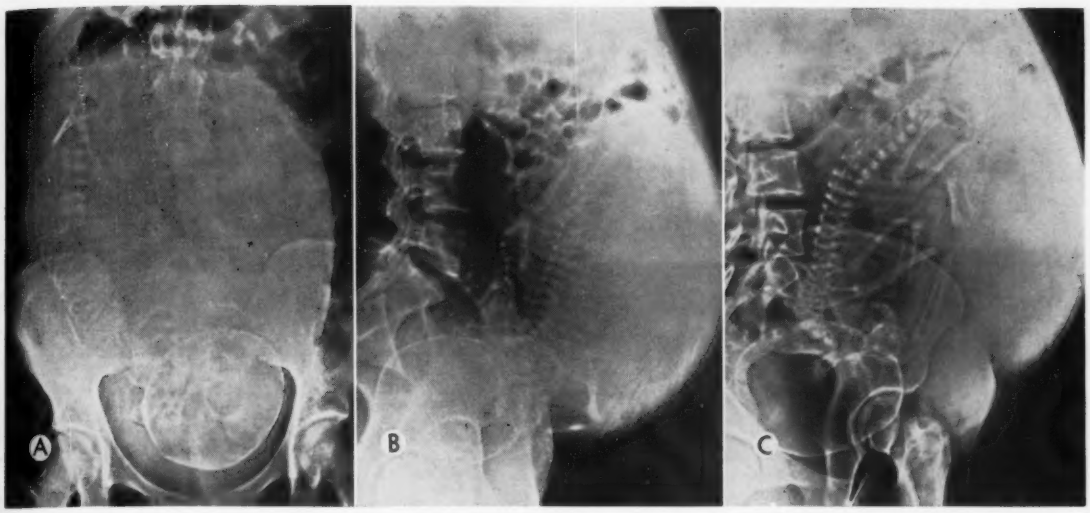


Fig. 5. Case v. (*A*, *B* and *C*) Premature separation of the placenta. The placenta is located anteriorly and measures 10 cm. in the oblique view (*C*), 8 cm. in the lateral view (*B*), and 14 cm. in the anteroposterior view (*A*). The fetus is displaced posteriorly and to the right, and has a compressed appearance which is most evident in the anteroposterior view (*A*). A 4×6 cm. retroplacental hematoma was found on delivery.

hour, and was followed ten hours later by mild irregular uterine contractions and low back pain. She also noted minimal bright red vaginal bleeding not exceeding 10 cc. in amount.

Past history. Two normal pregnancies were followed by a third premature delivery which resulted in a 2½ pound infant that died in less than twenty-four hours.

Physical examination. The uterus was soft and nontender and mild irregular uterine contractions were present. The height of the fundus was 24 cm. and the fetal heart tones were good.

Laboratory findings. A blood type was determined but not permanently recorded in the blood bank as the patient did not receive a transfusion. Other laboratory findings were not remarkable.

Placentographic findings (Fig. 5). Soft tissue placentography showed a single fetus of approximately eight months' gestation in cephalic presentation. The placenta was located anteriorly and measured 10 cm. in the oblique view, 8 cm. in the lateral view and 14 cm. in the anteroposterior view. The fetus was displaced posteriorly and to the right and had a compressed appearance which was most evident in the anteroposterior view.

Course. Spontaneous delivery occurred one day after entry, following an uneventful labor. The infant was healthy and weighed 4 pounds, 3 ounces. A retroplacental hematoma, measuring 4×6 cm., was noted behind the lower margin of the placenta.

Comment. Cases III and IV illustrate marked retroplacental bleeding associated with premature separation of the placenta. The similarity of the roentgen findings in these 2 cases and in erythroblastosis (Case I and II) is striking. It is apparent that the differentiation of these two conditions depends on a proper evaluation of the clinical picture.

In Case V a small retroplacental hematoma produced only minimal enlargement of the placental shadow. This was most evident in the anteroposterior view and to a lesser degree in the oblique view. The placental shadow was of normal thickness in the lateral view.

We have seen approximately 30 cases in which the roentgenographic diagnosis of premature separation was verified. Clinically, most of these patients were thought to have placenta previa. Fetal death is common in premature separation and early recognition is important. In addition, Page *et al.*[8] have recently emphasized early diagnosis and evacuation of the uterus in

cases of premature separation of the placenta to prevent maternal hypofibrinogenemia.

(c) *Syphilis.* Enlargement of the placenta may be caused by congenital syphilis, and prior to modern antiluetic therapy this probably was of frequent occurrence. During the period in which placentography has been performed at the Los Angeles County Hospital, *i.e.*, since 1949, congenital syphilis has become quite rare. In none of our cases in which placental enlargement was recognized has syphilis been found to be the etiologic agent.

(d) *Diabetes.* Babies born to diabetic mothers often are considerably larger than normal, and the tendency to overweight is so striking that the birth of a very large child always leads to the suspicion of diabetes. The reason for this overgrowth of the fetus is not well understood. It has been attributed to a number of factors such as maternal hyperglycemia and overactivity of the pituitary gland in the last two months of pregnancy. The placenta also becomes larger than normal. However, its increase in size is apparently not sufficient to produce roentgenographically recognizable enlargement. Although we have performed soft tissue placentography on many diabetic mothers, to date we have not been able to demonstrate any abnormalities of the placenta.

(e) *Placental Tumors.* Tumors of the placenta, other than hydatidiform mole or chorioepithelioma with which we are not concerned in this discussion, large enough to be demonstrated by placentography are exceedingly rare. None has been encountered by us.

(f) *Continued Growth of the Placenta after Fetal Death.* Occasionally following fetal death, the trophoblastic tissue of the placenta may remain viable and continue to grow, producing, in addition to a positive Aschheim-Zondek test, disproportionate enlargement of the placenta. In reviewing our material, we found only one likely example of this entity. However, this case is not being reported since adequate proof was not obtained.

2. Pseudo-enlargement of the placental shadow

(a) *Polyhydramnios.* Normally at term the amniotic fluid measures about 300 cc. Polyhydramnios, arbitrarily defined as amniotic fluid in excess of 1,000 cc., is usually associated with some abnormality of pregnancy. It is associated more commonly with anencephaly than any other fetal abnormality, but also occurs with twins and hydrops fetalis. Often, however, it occurs in an otherwise normal pregnancy in which there is no demonstrable exciting factor.

Case vi. K.S., twenty year old Negro female; gravida IV, para III; last normal menstrual period July 21, 1955; expected date of delivery April 28, 1956.

Present illness. The patient had had an uncomplicated pregnancy until the day of entry on March 14, 1956 when painless vaginal bleeding occurred with the loss of less than one-half cupful of blood.

Past history. Three previous pregnancies were uneventful.

Physical examination. The uterus was soft, nontender, and the height of the fundus was 25 cm. Fetal heart tones were good.

Laboratory findings. The blood was Rh positive.

Placentographic findings (Fig. 6). Soft tissue placentography showed a single fetus of approximately seven and one-half to eight months' gestation in cephalic presentation. The placental shadow was located anteriorly. Its maximum thickness was seen in the oblique views where it measured 12 cm. The fetus was displaced posteriorly and to the right. There was little, if any, fetal compression.

Course. Vaginal bleeding ceased immediately after entry and the patient was discharged. Spontaneous delivery of a normal 6 pound, 12 ounce male occurred on May 13, 1956. No abnormality of the placenta was noted. The obstetrician commented that there was excessive amniotic fluid.

Comment. Marked degrees of polyhydramnios are not usually difficult to detect roentgenographically. The uterine cavity is considerably larger than the fetus. By changing the maternal position, excessive mobility of the fetus within the uterine cavity can frequently be demonstrated.

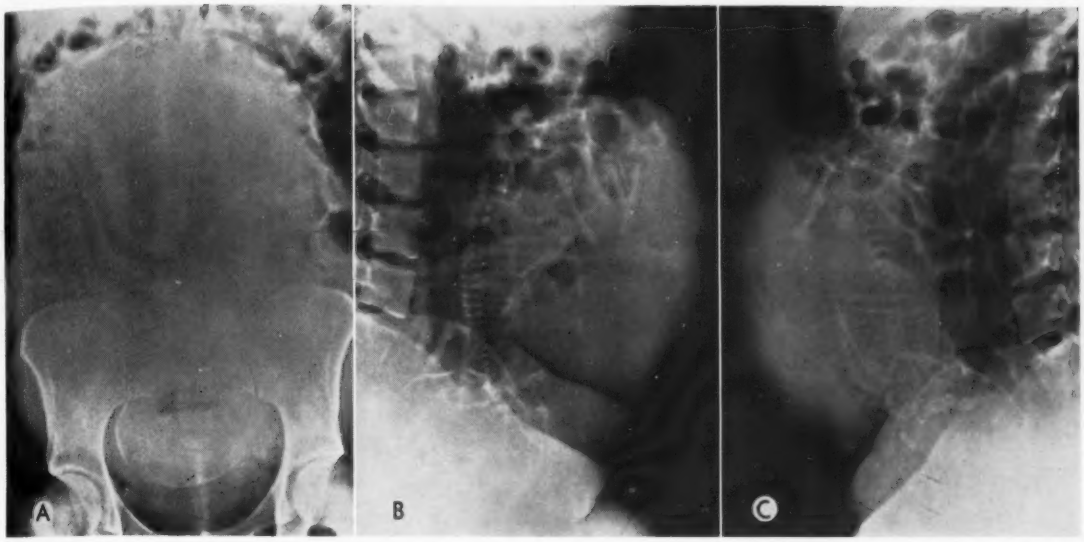


FIG. 6. Case VI. (*A*, *B* and *C*) Polyhydramnios. The placenta is located anteriorly and measures a maximum of 12 cm. in the oblique view (*C*). The fetus is displaced posteriorly and to the right but there is little, if any, compression.

With less marked polyhydramnios, however, the diagnosis is not readily established clinically or roentgenologically. It is in this type of case that we have had the greatest difficulty in differentiating polyhydramnios from true enlargement of the placenta. When excessive amounts of amniotic fluid collect in the region of the placenta, the roentgenographic changes simulate enlargement of the placenta. Unless a significant decrease in the apparent size of the placenta occurs with a change in the maternal position, an error in diagnosis may result. The compressed appearance of the fetus seen in the cases of true enlargement of the placenta is usually absent in polyhydramnios, providing an additional aid in differentiation. Unfortunately, the amniotic fluid was not accurately measured in Case VI, but it is felt that this case represents pseudo-enlargement of the placenta due to minimal polyhydramnios.

(b) *Abnormal Presentation of the Fetus.* Normally, in a cephalic presentation there is fairly close conformity between the fetal ovoid and the uterus. In other presentations, such as a breech or particularly a transverse lie, apposition of the uterine wall to the fetus is poor, and it becomes difficult or sometimes impossible to accurately localize the placenta, to say nothing of estimating its size.

(c) *Tumors or Abnormalities of the Uterus.* Tumors of the uterus, such as leiomyoma, are occasionally demonstrated by placentography as rounded or lobulated masses projecting from the surface of the uterus. Sometimes, however, such a tumor is not seen in profile, but rather is so located that its shadow blends with that of the placenta, and this may simulate placental enlargement.

CASE VII. E.F., thirty-five year old Caucasian female; gravida II, para I; last normal menstrual period June 13, 1955; expected date of delivery February 20, 1956.

Present illness. The patient entered the hospital on January 16, 1956 with a history of painless vaginal bleeding of twenty-four hours' duration. She estimated that she had lost about one cupful of blood.

Past history. One previous pregnancy had gone to term without complication. At that time, she was told that she had a uterine tumor.

Physical examination. The uterus was soft and nontender. No masses were noted and the height of the fundus was 32 cm. The fetal heart tones were good.

Laboratory findings. The blood was Rh positive.

Placentographic findings (Fig. 7). Soft tissue

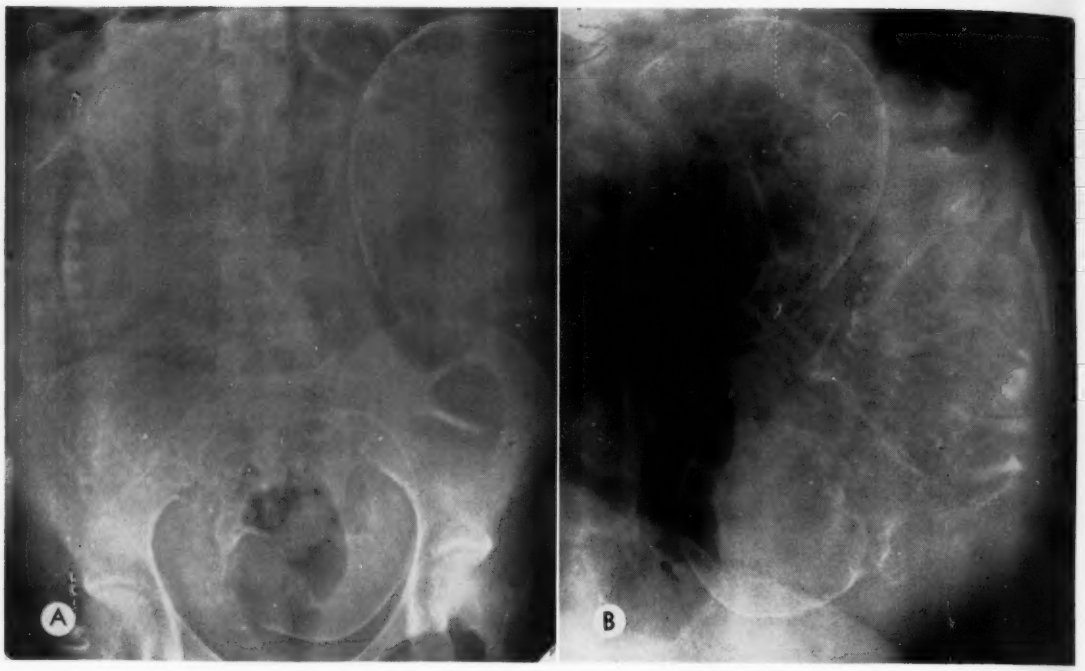


Fig. 7. Case VII. (*A* and *B*) Intramural leiomyoma. A 20 cm. calcified leiomyoma is located posterolaterally on the left side. The placenta is located anteriorly and there is no fetal compression.

placentography showed a single fetus of eight months' gestation in cephalic presentation. A 20 cm. calcified mass was located posterolaterally on the left. While the "placental shadow" could not be identified with certainty, it was thought to be located anteriorly. The fetus was displaced to the right, but there was no evidence of compression.

Course. Bleeding ceased shortly after entry, and a sterile vaginal examination revealed what was thought to represent a central placenta previa. The patient was discharged from the hospital and re-entered on February 19, 1956. She delivered a normal 6 pound, 7 ounce infant. There was no evidence of placenta previa. Postpartum hemorrhage of rather severe proportions developed, and a hysterectomy was done. A 20×24 cm. intramural fibroid was located in the left posterolateral portion of the uterus. The placenta was of normal size and consistency and was located high on the anterior surface of the uterus.

Comment. The history of a "pelvic tumor," calcification of the mass, and the lack of fetal compression permitted a correct antepartum diagnosis. However, if the leiomyoma had not been calcified and thus easily outlined, the roentgenograms could have been erroneously interpreted as showing a markedly enlarged placenta. It is of interest that on the present admission of the patient to the hospital, the tumor was not detected by physical examination.

(d) *Abnormalities of the Fetus.* Space-occupying lesions arising from the fetus, such as tumors, ascites, meningoceles, etc., may very closely simulate enlargement of the placenta by displacing and even compressing the fetus. In the following example, pseudo-enlargement of the placenta was caused by idiopathic fetal ascites.

Case VIII. F. C., seventeen year old Caucasian female; gravida I, para 0; last normal menstrual period July 4, 1956; expected date of delivery April 11, 1957.

Present illness. The pregnancy was uneventful until January 15, 1957 when painless postcoital bleeding occurred. She estimated that she had lost several hundred cubic centimeters of blood. Soon after the bleeding, fetal movement ceased.

Physical examination. The uterus was soft, nontender, and the height of the fundus was 25 cm. No fetal heart tones were heard.

Laboratory findings. The blood was Rh positive.

Placentographic findings (Fig. 8). Soft tissue placentography showed a single fetus of approximately six to seven months' gestation. The "placental shadow" was located posterolaterally and had a maximum thicknes of 12 cm. in the oblique views. The fetus was displaced anteriorly and to the right, and had a compressed appearance.

Course. A premature, stillborn infant of approximately six and one-half months' gestation was born on January 22, 1957. The fetal abdomen was markedly distended with ascitic fluid for which no cause could be determined. The placenta was small and there was no evidence of a retroplacental clot.

Comment. The roentgenographic findings in this case were indistinguishable from those seen in either premature separation of the placenta or erythroblastosis. In view of the positive maternal Rh factor, the antepartum roentgenologic and clinical diagnosis was premature separation. What was assumed to be an enlarged placenta was actually the distended fetal abdomen.

(e) *Prematurity*. In the earlier months of pregnancy the fetus does not fill the uterine cavity as completely as it does in the later months, making it difficult either to localize the placenta or assess its size. Under these circumstances, the diagnosis of placental enlargement should be made with considerable caution. The earlier the period of gestation, the greater the chance for error.

SUMMARY

1. Roentgenographic examination in the oblique views is frequently essential for the

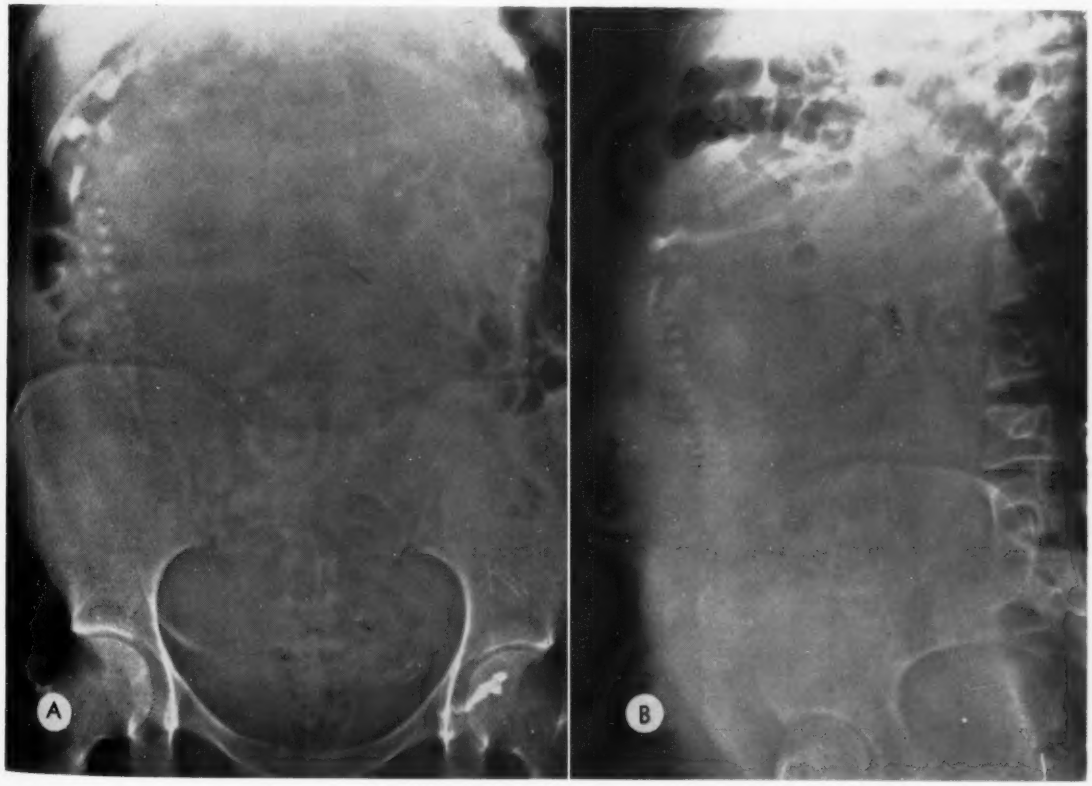


FIG. 8. Case VIII. (*A* and *B*) Fetal ascites. The placental shadow is located posterolaterally and measures 12 cm. in thickness in the oblique view (*B*). The fetus is displaced anteriorly and to the right and is compressed.

accurate determination of the size of the placenta.

2. The differentiation of true and pseudo-enlargement of the placental shadow is often difficult and sometimes impossible.

3. The diagnosis of true enlargement of the placental shadow should be limited to those cases where the findings are unequivocal.

4. Erythroblastosis and premature separation of the placenta are by far the most common causes of true enlargement of the placental shadow. When erythroblastosis can be excluded by laboratory means, a diagnosis of premature separation of the placenta can usually be inferred.

George Jacobson, M.D.
1200 North State Street
Los Angeles 33, California

REFERENCES

1. Bishop, P. A. Symposium on recent advances in gynecology and obstetrics; roentgenologic visualization of placenta. *S. Clin. North America*, 1945, *25*, 1394–1407.
2. Buxton, B. H., Hunt, R. R., and Potter, C. X-ray localization of placenta. *Am. J. Obst. & Gynec.*, 1942, *43*, 610–619.
3. De Lee, J. B., and Greenhill, J. P. The Principles and Practice of Obstetrics. Eighth edition. W. B. Saunders Company, Philadelphia, 1943.
4. Eastman, N. J. Williams Obstetrics. Tenth edition. Appleton-Century-Crofts, Inc., New York, 1950.
5. Greenhill, J. P. Obstetrics. Eleventh edition. W. B. Saunders Company, Philadelphia, 1955.
6. Hol, R. Placenta praevia. *Acta radiol.*, 1956, *45*, 106–116.
7. McDonald, E. J. Evaluation of placentography in late bleeding of pregnancy. *Radiology*, 1955, *64*, 826–830.
8. Page, E. W., King, E. B., and Merrill, J. A. Abruptio placentae; dangers of delay in delivery. *Obst. & Gynec.*, 1954, *3*, 385–393.
9. Qvist, C. F. Soft tissue radiography of placenta. *Acta radiol.*, 1952, *37*, 510–517.
10. Reid, F. Radiological localisation of placental site; normal implantation. *Brit. J. Radiol.*, 1949, *22*, 557–566
11. Snow, W., and Powell, C. B. Roentgen visualization of placenta. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 37–40.
12. Snow, W., and Rosensohn, M. Roentgenologic visualization of soft tissues in pregnancy. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 709–717.

VOL. 80, NO. 4

PELVIC ANGIOGRAPHY—WITH PARTICULAR REFERENCE TO ITS VALUE IN INTRAUTERINE PREGNANCY AFTER THE FIFTH MONTH OF GESTATION*

By K. E. HODGE, M.B., F.R.C.P.(C), D.M.R.D.†
TORONTO, ONTARIO, CANADA

IN 1931 dos Santos and his colleagues,[8] published the monograph *Artériographie des membres et de l'aorte abdominale*. Numerous subsequent articles appeared on angiography of the pelvic vessels,[3,4,5,11,17,19] culminating in 1955 in Fernström's[9] treatise *Arteriography of the Uterine Artery*. This latter work evoked a very favorable annotation in the *British Medical Journal*,[2] containing the comment that "The experience gained in this considerable study has been beautifully presented in the monograph, which also contains a survey of the literature, a description of technique and the complications encountered, which were not serious, as well as an impartial statement on the diagnostic value of the new methods." Four hundred and forty-eight cases comprised the basis of Fernström's work.

The considerably smaller total number of cases we have examined by pelvic angiography would make any attempt at encroachment upon the ground covered by Fernström presumptuous; although, when considered in relationship to the practical value of pelvic angiography in cases of intrauterine pregnancy, which was the primary object of our study, the discrepancy is not so great. Fernström carried out 17 satisfactory examinations on patients between the fifth and tenth lunar months of pregnancy on whom reliable information was subsequently obtained as to the actual site of placental implantation, whereas we carried out 13 such examinations.

De Villiers and Brink[7] reported 25 cases of suspected placenta previa examined by pelvic angiography, and Brink and Lodeman[6] recently stated that they "have used the arterial route for placental location in almost 100 cases," and regard it as superior to plain film methods. We regard angiography as ancillary to the gravitational plain film technique, and therefore consider it necessary in a relatively small number of cases. A method requiring arterial puncture and the injection of contrast medium should not be used routinely, especially as the gravitational technique is accurate in the great majority of cases. Those few cases in which it is likely to fail form a definite group in which angiography can be of real help.

This paper is consequently presented as an expression of our own experiences with pelvic angiography and as a description of our own method.

Fernström, in describing his technique, says "Since 1952 we have been using the catheter replacement method of percutaneous arteriography described by Seldinger,"[18] his reason being that this permits simultaneous filling of both uterine arteries at one examination. He indicates that in his early work, arteriography was done by percutaneous retrograde injection of the iliac artery, but as this usually resulted in filling of the ipsolateral uterine artery only, it was often necessary to repeat the procedure on the opposite side.

Norman[17] states that the catheter replacement method is nevertheless "more complicated and time-consuming than that using simple percutaneous injection into the femoral artery" and it therefore has considerable disadvantages when examining pregnant women.

* From the Departments of Radiology, Toronto General Hospital and University of Toronto.
† Chief Radiologist, Sunnybrook Hospital, Toronto, and Associate in Radiology, University of Toronto.

Excellent demonstrations of the pelvic vessels have been obtained by translumbar aortography,[11] but its employment in the diagnosis of placenta previa and other conditions of the uterus and adnexa has been very limited. Most obstetricians would rather not refer their patients for an examination that usually entails a general anesthetic and necessitates their being placed in a prone position on a roentgenographic table for varying lengths of time. Translumbar aortography moreover carries with it certain intrinsic hazards which, although not frequently encountered, cannot be disregarded.[10,14,15]

For the above reasons retrograde injection of the iliac arteries by percutaneous femoral puncture has definite advantages over translumbar aortography and the catheter replacement technique. Its one great disadvantage in the past has been that only the ipsolateral pelvic vessels could be demonstrated consistently.

Sutton,[19] in a preliminary report on *Placental and Pelvic Angiography by Retrograde Percutaneous Injection of the Femoral Artery* considers the use of a mechanical injector as undesirable because he feels that manual injection gives better control, and the injector can stop at once should it be felt that the needle point has slipped out of the lumen of the artery. He states that successful manual injection as high as the aorta needs considerable force, and the injector requires fairly powerful muscles.

We used Sutton's method on one patient, and, while wholeheartedly agreeing that powerful muscles are required, found that in such circumstances of physical exertion, we had no more real control over the injection than when using a mechanical injector. Furthermore, it is extremely difficult to tell during an injection lasting only about three seconds whether or not the needle—which is connected to the syringe by flexible tubing—has slipped out of the lumen of the artery.

A mechanical injector similar to that described by Lentino and Lentino[13] was therefore used and the needle threaded up the iliac artery in a cephalic direction far enough to prevent the recoil of injection from forcing it out of the lumen; in addition, less force was needed to carry contrast medium the shorter distance across the aortic bifurcation into the contralateral vessels. This method worked well on our first 2 patients, who were thin women in whom the femoral artery could be easily palpated and the needle readily threaded retrogradely into the external iliac artery. Injection of contrast medium resulted in excellent filling of the iliac vessels on both sides.

The next 2 patients were obese, and although the femoral arteries were easily punctured in each case, it was impossible to thread the needle retrogradely into the iliac artery for any distance. In both cases mechanical injection resulted in only a small amount of contrast medium entering the lumen of the ipsolateral vessel before the needle recoiled out of the artery and deposited the remainder into surrounding soft tissues, fortunately without greater ill effects to either patient than local discomfort lasting a few hours.

A 17 s.w.g. lumbar puncture needle 11.5 cm. long and its stylet were therefore made into an arterial cannula and trocar (Fig. 1).

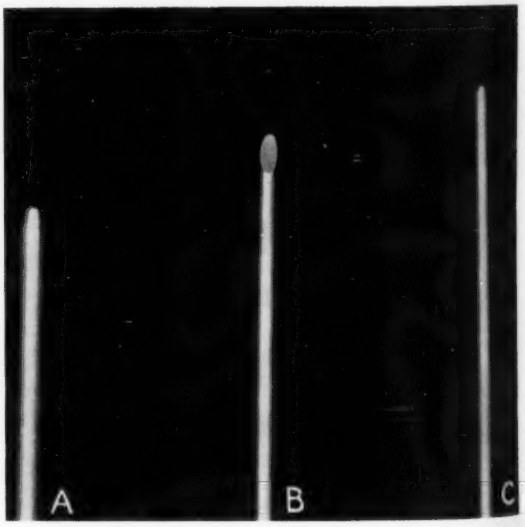


FIG. 1. Tips of arterial puncturing apparatus: A, cannula; B, puncturing trocar; and C, blunt ended probe.

Having punctured the artery, the trocar could then be withdrawn and replaced by a blunt-ended probe 19 cm. long and of the same gauge wire. This blunt flexible probe could be easily threaded up the lumen of the iliac artery far beyond the tip of the cannula, as it could not pierce the intima. The cannula could then be threaded on this probe in much the same way that a Smith-Petersen pin is directed by its guide wire.

The trocar, cannula and probe allowed rapid and successful examinations to be easily obtained, even on obese patients with femoral arteries that were mobile and difficult to palpate.

TECHNIQUE

Before the arterial puncture is made, the cannula, trocar and guide wire are immersed in 1:1,000 solution of heparin to prevent clotting. Also before puncture, blood pressure cuffs are applied above both knees and, when the cannula is in position in the artery and immediately before injection, these are inflated to just above systolic blood pressure; they are released immediately after injection. Following satisfactory puncture and inflation of the blood pressure cuffs, the cannula is connected by flexible polyethylene tubing to the manual injector, and 30 cc. of contrast medium is injected. To carry the contrast medium over the aortic bifurcation into both common iliac arteries without excess filling of the lower aorta, it is necessary to inject it in approximately 3 seconds.

We have used a 50 per cent solution of diodrast in all but one case, and this concentration has caused most patients to experience varying degrees of burning in the lower lumbar region and legs for a few seconds after injection. In one case we used a 35 per cent solution quite satisfactorily and would feel that in many cases this is preferable, except for those very large patients in whom a 50 per cent solution may give better visualization.

Because all but one of our cases have been examined during pregnancy, it was considered advisable to make only two roentgenograms in the anteroposterior projection. Roentgenograms in the lateral views were not obtained because of the technical difficulties involved and the considerably greater amount of radiation that would have been needed relative to the possible benefits to be gained. As indicated formerly,[12] the real practical problem in the majority of patients we have examined has been the differentiation between major degrees of placenta previa and minor degrees or absence of placenta previa, and it was felt that anteroposterior roentgenograms alone would usually be adequate; we do nevertheless appreciate the great advantages of lateral roentgenograms if these could be easily obtained without undue radiation to the patient.

The first roentgenogram is exposed a split second after the end of the injection, and the second approximately three seconds later. This results in nearly all cases in the first roentgenogram showing good filling of the arteries and the second showing good filling of the placental sinuses.

We tried three methods of film changing. On one occasion an Elema machine was used but the 12×14 inch serial roentgenograms did not cover a large enough area. Next, a cassette tunnel with a stationary grid was tried but the roentgenographic quality was not satisfactory. The best results by far have been obtained by a practiced technician changing standard 14×17 inch cassettes by hand in an ordinary Bucky tray with a moving grid. This can readily be accomplished within three seconds.

In summary, therefore, the technique which evolved is: 1. Suitable premedication of the patient; no general anesthetic is required but local infiltration is used. 2. Rinsing of the arterial cannula, trocar and guide wire in 1:1,000 heparin solution prior to the arterial puncture. 3. Percutaneous femoral puncture and retrograde cannulation of the ipsolateral external iliac artery as described. 4. Injection of 30 cc. of 35 per cent diodrast with a manual injector. 5. Exposure of two 14×17 inch films at three second intervals. 6. Slow perfusion

of the cannula with saline until the films are developed. 7. If the roentgenograms are satisfactory, the cannula is withdrawn and the site of percutaneous puncture manually compressed for five minutes.

COMPLICATIONS

Our most outstanding complication was in one of the early cases. While still using a plain needle, we omitted to rinse it in heparin solution beforehand and, following successful puncture, were slow in threading the needle into the iliac artery. The spurts of blood became extremely sluggish, but because of the good puncture we continued with the injection and did produce excellent visualization of a normally implanted placenta. Approximately eight hours after the injection, the patient complained of pain in her right iliac fossa. A small area of skin in this region was seen to have become completely white, and during the next few days this skin and the underlying superficial tissues sloughed away. The wound healed so slowly over the course of the next few weeks that it was eventually closed surgically. It is obvious that a small clot had been projected into the right superficial epigastric artery and had resulted in a localized area of infarction and necrosis in the superficial abdominal wall.

This complication need never happen. The puncturing apparatus should always be rinsed in 1:1,000 heparin solution beforehand, and it is also much easier to thread the cannula rapidly in a retrograde manner than a plain needle, thereby avoiding thrombus formation. If by chance the spurts of blood from the cannula do begin to slow down, the injection should not be made.

A difficult matter to assess is that of possible induction of labor. Norman[17] commenting on Hartnett's[11] aortographic study said "the greatest drawback of the method, however, is that, judging by Hartnett's account, the injection of contrast substance (70% Diodrast) into the pelvic arteries very often induces labour." Norman indicated that lower concentrations of contrast medium (42 per cent) are more satisfactory and stated that "We found the injection of 30 ml. Umbradil (Dijodonum) sufficient, and this dose did not produce any discernible foetal reaction or uterine contraction."

Of our own cases, 14 had successful angiographies carried out during pregnancy and 5 went on to full term deliveries of normal babies. One examination during pregnancy was for a condition other than suspected placenta previa, as is discussed later.

Thirteen were examined for suspected placenta previa and all were bleeding at the time of admission. Five were diagnosed by angiography as having central placenta previa and the diagnosis was confirmed clinically in each. In 3 of the 5, the bleeding did not increase after angiography. Of these 3, one had a vaginal hysterotomy three days later for continued bleeding, the second had an emergency cesarean section five days later because of severe hemorrhage, and the third aborted three weeks later. In one, severe hemorrhage occurred an hour after angiography, necessitating an emergency cesarean section. The remaining patient aborted twenty-four hours later. No living children were obtained from these 5 cases.

The remaining 8 cases of suspected placenta previa did not have this condition, but 4 had premature deliveries. In none of these patients did angiography increase the bleeding for which they were admitted; 1 baby was delivered four days after examination, and 2 three days after, but all 3 died shortly after birth. In the other case a premature but otherwise normal child was delivered four weeks after examination at thirty-five weeks' gestation, and survived.

It is also of interest to note that the stage of gestation at which the examinations were performed appeared to bear no definite relationship to the outcome. Of those progressing to full-term deliveries the average stage of examination was twenty-seven weeks and varied between twenty-three and thirty-two weeks, while of those having premature deliveries the average stage was twenty-eight weeks, varying between twenty-one and thirty-two weeks.

It is therefore difficult to find a definite

causal relationship between angiography and any of the premature deliveries, with the exception of 2 of the central placenta previa patients. One of these started to bleed severely again an hour after the examination and the other began to bleed more profusely a few hours after.

The proved placenta previa patients were all bleeding fairly freely when admitted to the hospital, and all followed courses which they might well have done without angiography. The same may also be said of those cases of subsequent premature delivery found not to have placenta previa.

In 2 of our early cases, as already indicated, a good femoral puncture was obtained but only a small amount of contrast medium entered the iliac vessels before the recoil from injection forced the needle out of the artery causing extravasation into the surrounding tissues with resultant local tenderness for a few hours afterwards, although no more serious damage to the patients occurred. No other complications occurred apart from a few minor ones of the type described by Fernström, such as slight nausea.

The injection itself should not lead to complications. Contrast medium in large concentrations cannot enter major branches of the upper abdominal aorta, as it only fills the lower aorta. Dissection of the media of the iliac arteries is exceedingly improbable when using a blunt cannula which is well threaded into the lumen of the vessel.

INDICATIONS FOR PELVIC ANGIOGRAPHY

The extent of the possible applications of pelvic angiography in the diagnosis of disease of the uterus and adnexa is indicated by the full title of Fernström's[9] monograph.

Sutton,[19] in his paper describing 3 patients examined by pelvic angiography, said that retrograde femoral angiography permits investigation of pelvic tumors without the necessity for general anesthesia and lumbar aortography. From our own material, we are not in a position to discuss the value of pelvic angiography in the differentiation of malignant tumors from benign lesions, nor in the determination of the extent of any such pelvic lesion. The value of angiography in making differentiations in other regions of the body is nevertheless well established, and its application to pelvic disease would, therefore, seem to be a logical step.

The indication for pelvic angiography in our own cases has been predominantly the localization of the placenta. In a recent study of patients examined for suspected placenta previa by the gravitational displacement technique,[12] it was indicated that despite the diagnostic accuracy of this method after thirty-two weeks' gestation, the uncertainties of diagnosis before that time and in occasional cases of abnormal presentation are such that we have occasionally employed pelvic angiography. An indication of the extent of our use of angiography in placental localization can be judged from the fact that it was found necessary to attempt examination of only 17 patients by this means during a two year period, during which time approximately 120 patients were examined by the gravitational method. There were undoubtedly more cases of suspected placenta previa before the thirty-second week of gestation which were admitted to the Toronto General Hospital during the same period, but these were not referred to the radiologist because the clinicians knew from past experience that the gravitational method would probably not yield conclusive results in such circumstances, yet they were reticent to subject their patients to angiography.

This clearly raises questions concerning the real value of the method in the diagnosis of placenta previa. The placenta is certainly better demonstrated by angiography than by any other means, but the technique necessitates percutaneous arterial puncture and the injection of a contrast medium, so that it carries certain discomforts and possible complications, even though these may be slight. Is it, therefore, worthwhile employing angiography if conservative

treatment in a hospital until the thirty-second week of gestation allows a 95 per cent accuracy in the diagnosis or exclusion of placenta previa by the simple and safe gravitational technique; or, alternatively, do the advantages of angiography in giving an immediate and accurate diagnosis outweigh the disadvantages of extra weeks in hospital? Only individual obstetricians and radiologists, knowing fully the circumstances of their own patients, can answer these questions satisfactorily.

Two patients in our series were examined for conditions other than suspected placenta previa. As is discussed below, one of these was for the diagnosis of an unusually large abdominal mass occurring during the course of an otherwise uneventful pregnancy, and the other was for a pelvic mass persisting in the postpartum period.

MATERIAL AND INTERPRETATION OF ROENTGENOGRAMS

Fifteen patients were successfully examined by angiography although 19 examinations were attempted. We thus had 4 failures; all in cases referred for suspected placenta previa. Two of these occurred early in our series when a plain needle was still in use for arterial puncture; this slipped out of the lumen during injection on both occasions. Of the other two failures, both were in extremely apprehensive young women who, despite premedication, became impossible to manage after the percutaneous puncture had been made. The injections were therefore not carried out, as it was felt certain that satisfactory roentgenograms could not possibly be obtained in the circumstances.

Cases of Suspected Placenta Previa. Thirteen of our patients were successfully examined for suspected placenta previa, all of them because of vaginal bleeding. Gravitational placentography had already yielded equivocal results in 9, because of the small size of the fetuses. In the other 4, localization by this method had not been attempted as it was felt that the fetuses were too small for successful results to be obtained. The examinations were carried out at the thirty-second week of gestation in 2 cases, and between the twenty-first and thirty-second week in the others. The outcome of all these cases has been described in the paragraphs discussing the complications of pelvic angiography.

A central placenta previa was diagnosed in 5 cases and confirmed clinically in each; and in 7 cases placenta previa was excluded by angiography, these diagnoses also being confirmed clinically. In one case a left lateral wall placenta, not constituting a placenta previa, was diagnosed by angiography. The patient continued to bleed severely and a cesarean section was performed. The placenta was found to be on the left anterolateral uterine wall, but its margin was extending down to the region of the internal os, constituting a major degree of placenta previa.

Recognition of the placenta on the angiograms presents no difficulty, as both the arterial and the sinus-filling phases give characteristic appearances (Fig. 2, *A*, *B*, *C* and *D*; 3, *A*, *B* and *C*; 4, *A*, *B* and *C*; and 5, *A*, *B* and *C*).

The most characteristic feature of the arterial phase is the increasing tortuosity of the uterine vessels as they converge upon the placenta, becoming exceedingly tortuous and often forming into numerous spirals in the immediate vicinity of the placenta. So characteristic is this appearance that in one case of central placenta previa the diagnosis was confidently made from the appearances of the arterial phase alone, despite the sinus-filling phase having been missed by poor film changing techniques. The appearances of the arteries running toward low-lying placentas differ in no way from those of placentas situated on the upper uterine segment, except that they arise from the main uterine vessels lower down in the pelvis.

In all our cases, both uterine arteries contributed to the placental blood supply. In those cases of normal placental implantation the greatest supply was derived from the ipsolateral uterine vessels (Fig. 4*A* and

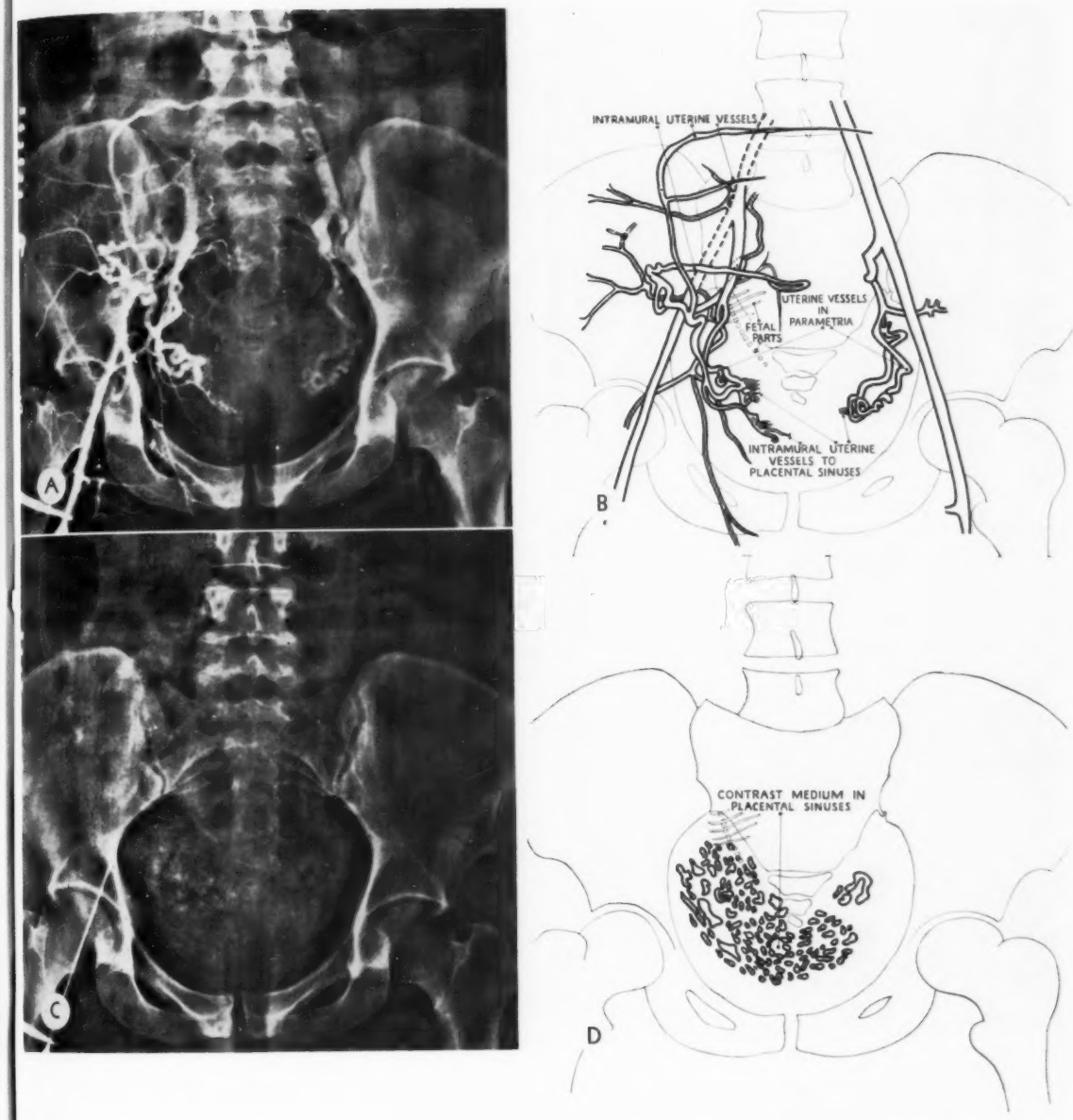


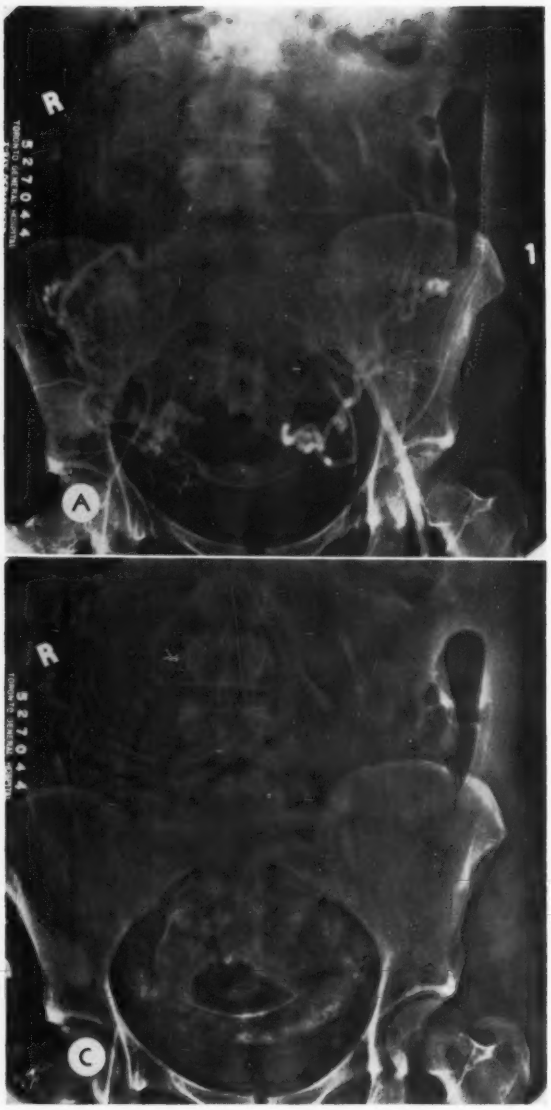
FIG. 2. Central placenta previa at 23 weeks of gestation. (*A*) Arterial phase angiogram. (*B*) Drawing of arterial phase. (*C*) Sinus phase. (*D*) Drawing of sinus phase.

5*A*), but in those with central placenta previa it appeared to come approximately equally from both sides (Fig. 2*A* and 3*A*).

In all our cases examined during pregnancy, the uterine arteries were seen to be wide, and thus in keeping with Fernström's[9] findings that their width is increased in the second half of pregnancy.

We did not consistently visualize the main trunks of the uterine arteries running along the lateral margins of the uterus. In most cases this was of academic interest only, and the real diagnostic value lay in the demonstration of the intramural branches.

Uterine Fibromyoma Associated with Pregnancy. The patient was a twenty-eight year old woman who had had two previous normal



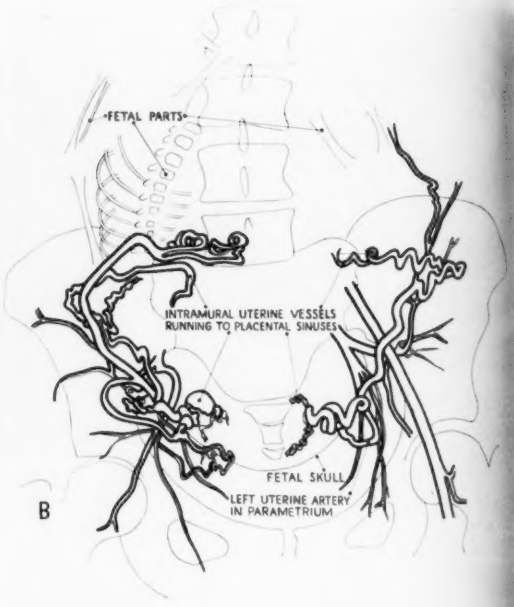


FIG. 3. Central placenta previa at 29 weeks of gestation. (*A*) Arterial phase angiogram. (*B*) Drawing of arterial phase. (*C*) Sinus phase. (*A* and *C* reproduced by permission from *Canad. M. A. J.* and *Radiology*.)

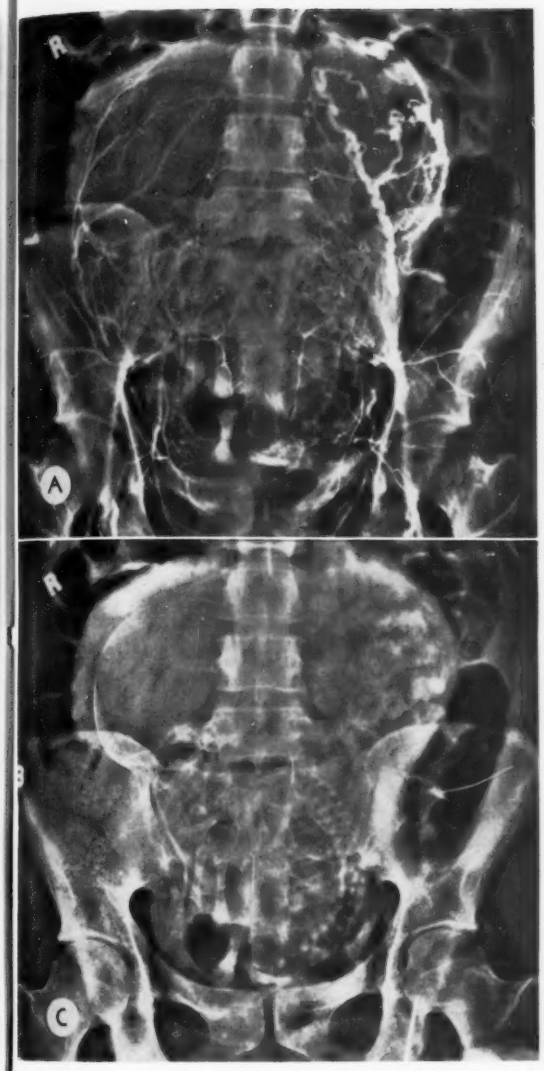
pregnancies. She presented at the twenty-sixth week of her third pregnancy with slight general abdominal pain and breathlessness, and complaining that her abdomen was as large as it had been at the eighth month of her previous pregnancies.

On examination her abdomen was protuberant, and a visible mass was present on each side of the umbilicus. On palpation, the mass on the left was round, smooth and approximately 15 cm. in diameter while that on the right consisted of the fetus *in utero*. The differential clinical diagnosis was between a left ovarian cyst and a uterine fibromyoma, with the impression that it was probably an ovarian cyst.

A preliminary plain roentgenogram showed a single normal appearing fetus in the right side of the abdomen, compatible with a gestation period of approximately twenty-six weeks and a soft tissue shadow in the left side of the abdomen having a smooth convex lateral border which appeared to be continuous with the uterus.

It was felt clinically that a precise diagnosis was necessary for the satisfactory management of the case and that pelvic angiography was therefore justifiable. This was carried out with ease and without complications (Fig. 5, *A*, *B* and *C*).

The arterial phase (Fig. 5*A*) showed a right



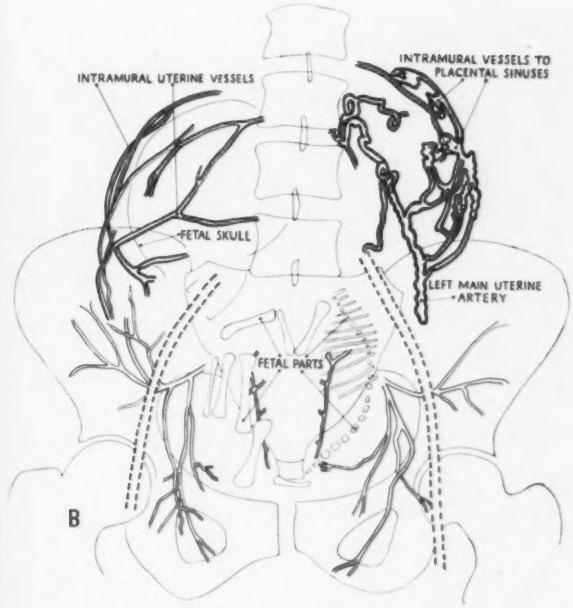
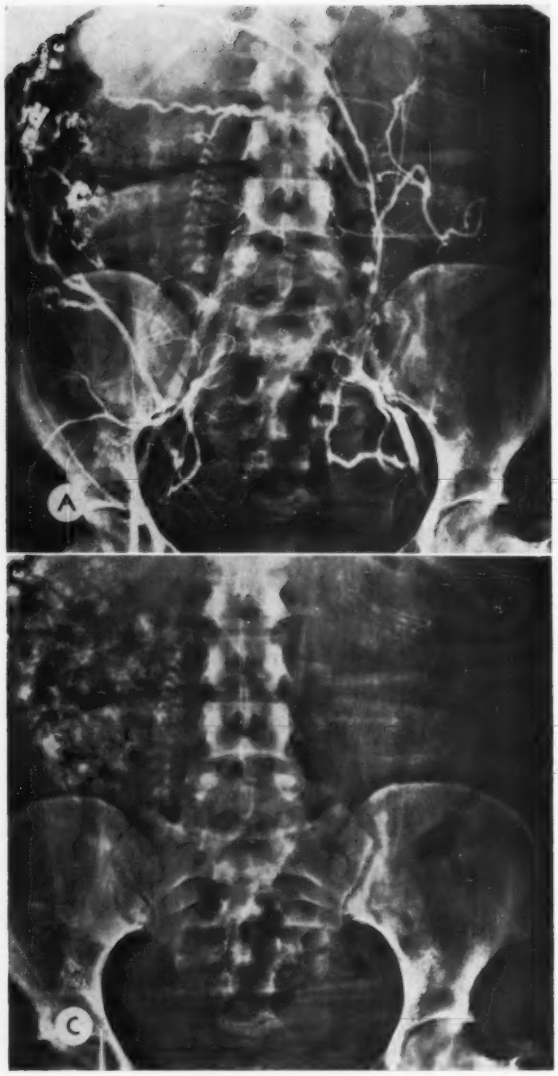


FIG. 4. Left cornual placenta at 31 weeks of gestation. (*A*) Arterial phase angiogram. (*B*) Drawing of arterial phase. (*C*) Sinus phase.

lateral wall placenta supplied chiefly from the right main uterine artery but with branches from the left also. A large branch from the left uterine artery, arising approximately half-way between the pelvic brim and the fundus, was seen to project laterally towards a mass on the left side of the body of the uterus and to course around the tumor and send branches into it. The intrinsic structure of these vessels appeared normal; and as Fernström[9] indicates, it may be difficult to distinguish capsular blood vessels from intrinsic arteries and it is therefore expedient to term them all "tumor vessels." The second roentgenogram (Fig. 5*C*) showed a normal although somewhat scanty capillary pattern within the mass, which was more clearly outlined than before because of the contrast medium within its substance. It was seen to form part of the uterine wall. The normal intrinsic appearances of the blood vessels of this mass and the fact that it was within the uterine wall led to a diagnosis of a benign uterine tumor composed of relatively normal tissues, and therefore a fibromyoma.

Because of its nature and site, operative intervention was not considered necessary and the patient progressed to a full-term normal delivery without complications.

After delivery, bimanual palpation was performed and the obstetrician reported that the mass felt like a fibroid. During the postpartum period it became smaller in size as the uterus



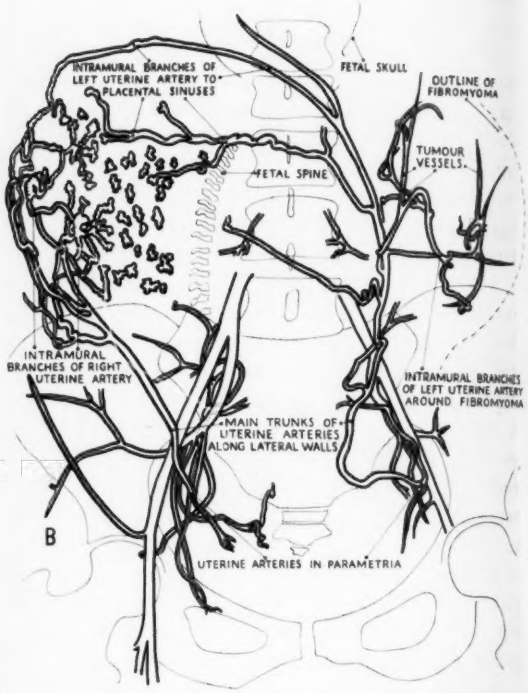

INTRAMURAL BRANCHES OF LEFT UTERINE ARTERY TO PLACENTAL SINUSES
FETAL SKULL
OUTLINE OF FIBROMYOMA
TUMOUR VESSELS
FETAL SPINE
INTRAMURAL BRANCHES OF RIGHT UTERINE ARTERY
INTRAMURAL BRANCHES OF LEFT UTERINE ARTERY AROUND FIBROMYOMA
MAIN TRUNKS OF UTERINE ARTERIES ALONG LATERAL WALLS
B
UTERINE ARTERIES IN PARAMETRIA

Fig. 5. Left lateral uterine fibromyoma and right lateral placenta at 26 weeks of gestation. (*A*) Arterial phase angiogram. (*B*) Composite drawing of *A* and *C*. (*C*) Capillary-filling phase of fibromyoma; sinus-filling phase of placenta.

involuted, and eventually became impalpable. Microscopic proof was not obtained but the mass was regarded as undoubtedly being a fibromyoma.

Ovarian Tumor Examined in Postpartum Period. The patient was a twenty-two year old woman who had been delivered of a normal full-term child six weeks previously. During pregnancy she had an excessively protuberant abdomen which remained prominent after delivery. Dilatation and curettage five weeks after delivery revealed only moderate uterine enlargement and it was therefore felt that the protuberant abdomen was due to an ovarian tumor. On physical examination the abdomen was soft, and a fluctuant palpable mass was arising out of the pelvis and extending to the level of the umbilicus, being particularly large in the left side of the abdomen. Because the precise diagnosis was undetermined, pelvic angiography was decided upon and was performed without difficulty.

The arterial phase (Fig. 6) showed the left uterine artery to be moderately tortuous in the parametrium and along the left lateral uterine wall, although its origin was narrow, as though in spasm.

The right uterine artery followed a straight course in the parametrium but was quite tortuous along the right lateral uterine wall. The uterus was situated on the left of the midline and the few intramural branches that were

visualized showed it to be moderately but not markedly enlarged.

A long adnexal branch of the left uterine artery was seen extending in a fairly tortuous fashion upwards out of the pelvis and ending in fine branches above the level of the left sacral ala. A smaller adnexal branch was demonstrated extending upwards in the midline for a short distance from the right main uterine trunk.

It was interesting to note that the right uterine artery appeared to divide into two main branches in the parametrium. It is realized that the smaller of the two branches could possibly represent the obliterated hypogastric artery, or a rare reduplication of the uterine artery, or even an abnormal appearing vesical artery; but there are various points against these latter interpretations, and this minor anomaly is not relevant to the diagnosis.

The roentgenogram of the capillary-filling phase showed no abnormal tumor vessels, and the region of the palpable mass was in fact remarkably free of any contrast medium.

A diagnosis was therefore made of a large left adnexal tumor, deriving a considerable part of its blood supply from adnexal branches of the left uterine artery. The absence of tumor vessels indicated that the tumor was probably nonsolid and therefore most probably an ovarian cyst.

The patient was operated upon and a multilobulated smooth tumor mass, about 30 cm. in diameter was seen to be arising from the left adnexal region. Pseudomyxoma peritonei was scattered over the peritoneal surface of the bowel, greater omentum and posterior peritoneal wall. The mass was removed and a left salpingo-oophorectomy was performed. The patient made an uneventful recovery. The pathologic report stated that the tumor was a pseudomucinous cystadenoma of the ovary.

Comment. According to Fernström[9] there does not seem to be a relationship between the width or course of the uterine arteries and the size or type of a tumor. He states that the width of the ramus on the side of the tumor is generally greater in cases of solid than nonsolid tumors, and that in the former it varies from 1.5–6.0 mm., while in the latter from 0.5–1.5 mm. In our case of a nonsolid tumor the left ramus measured 2.0 mm. at its origin and was, therefore, slightly larger than Fernström's measurements for this type of tumor.

Fernström also states that evidence of

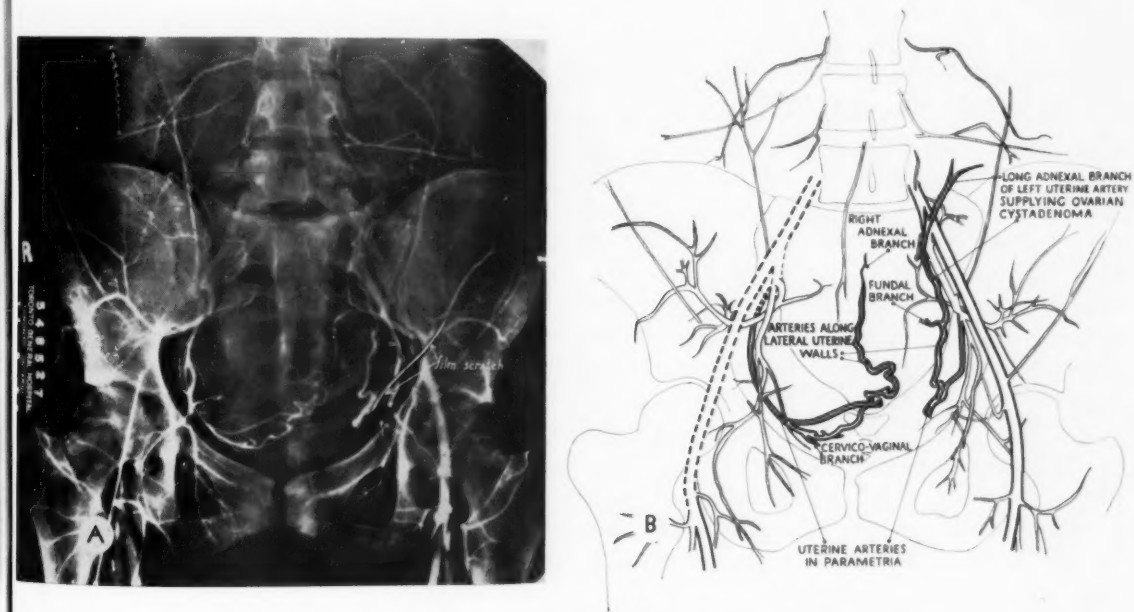


Fig. 6. Left ovarian pseudomucinous cystadenoma shown six weeks post partum. (*A*) Arterial phase angiogram. (*B*) Drawing of arterial phase.

branching of the ramus on the side of the tumor is especially visible in cases of solid tumor, and that a nontortuous and arched ramus is identified predominantly in cases of large tumor. In our case of a large cystic tumor, the left adnexal branch was moderately tortuous, was not unduly arched, but did show terminal branching.

DISCUSSION

A simple method of pelvic angiography using an arterial cannula, trocar and probe is described. It allows an examination to be carried out in thirty minutes or less from the time the patient is put on the roentgenographic table until she is taken off, and gives the advantages of bilateral filling of the pelvic vesssels as with the Seldinger catheter replacement technique, combined with the ease and convenience of percutaneous superficial femoral arteriography.

Our experience includes the following:

Examinations attempted		19
Examinations successful		15
During pregnancy (5th–8th mo.)	14	
For suspected placenta previa	13	
For associated abdominal mass	1	
For persistent postpartum mass	1	
Failures		4

All early cases in series and during development of technique; all for suspected placenta previa.

One major complication was encountered early in the series due to slowness in manipulation together with a failure to immerse the puncturing needle in heparin solution beforehand. This resulted in a small embolus entering a terminal branch of the right superficial epigastric artery, causing a local infarct with necrosis of the superficial tissues of the right lower quadrant of the abdomen. This complication could have been avoided. Otherwise, only transient minor complications were encountered such as might be expected with percutaneous injection of diodrast for any other purpose, as in intravenous pyelography.

We have used pelvic angiography successfully for placental localization between the fifth and eighth months of gestation in 13 cases. Five cases of central placenta previa and 7 cases of normal placental implantation were correctly diagnosed; there was one error in which a left lateral wall placenta without placenta previa was diagnosed, but at operation the lower margin of the placenta was found to be in the region of the internal os.

After the eighth month of gestation the gravitational plain film method of placentography is accurate in the diagnosis and exclusion of major degrees of placenta previa and angiography is not justifiable. Whether angiography is indicated for placental localization before that time will depend on the desirability of avoiding possible unnecessary hospitalization in any given case of suspected placenta previa and will thus depend upon individual circumstances.

In one case angiography was used to make an exact diagnosis of an abdominal tumor occurring in association with pregnancy. The clinical diagnosis rested between a uterine fibromyoma and an ovarian tumor, and angiography showed conclusively that it was a fibromyoma on the upper uterine segment. Angiography was, therefore, of great value in this case as it indicated the precise diagnosis and the need for conservative treatment as opposed to operative intervention.

In the other the procedure was employed in the differential diagnosis of an abdominal mass six weeks after a normal full-term delivery. A correct diagnosis of an ovarian cyst was made.

We have not employed pelvic angiography in the diagnosis of other pelvic lesions, but the diagnostic value of angiography in other parts of the body is so well established that this application would seem to be a logical step.

The detailed anatomy of vessels other than those directly related to the diagnosis has not been labelled on the drawings. For their identification, reference to the excellent paper on *The Arteries of the Abdomen, Pelvis and Thigh* by Muller and Figley[16] is suggested.

SUMMARY

A simple method of bilateral pelvic angiography by percutaneous femoral puncture is described. The indications, complications, and failures are discussed.

Fifteen successful examinations are reported; 13 were for suspected placenta previa between the fifth and eighth month of gestation; one was for the diagnosis of an abdominal tumor occurring in association with pregnancy; and the other was for an abdominal mass persisting six weeks after a normal full-term delivery.

Department of Radiology
Sunnybrook Hospital
Toronto 12, Ontario
Canada

I wish to express my thanks to Prof. A. C. Singleton, Prof. D. E. Cannell and the other radiologists and obstetricians of the Toronto General Hospital for the help and encouragement they have given me, and to the technicians who gave much valuable assistance.

I should also like to thank my wife, Annemarie, for the drawings, Dr. Sheila Hill for her help with the obstetric aspects, and the Log-Etronic Corporation for reproducing the roentgenograms.

REFERENCES

1. Allemang, W. H., Hodge, K. E., and Harkins, J. L. Evaluation of accuracy of diagnosis in placenta praevia. *Canad. M.A.J.*, 1956, *75*, 904–909.
2. Annotation. Pelvic arteriography. *Brit. M. J.*, 1955, *2*, 957.
3. Borell, U., Fernström, I., Lindblom K., and Westman, A. Diagnostic value of arteriography of iliac artery in gynaecology and obstetrics. *Acta radiol.*, 1952, *38*, 247–263.
4. Borell, U., and Fernström, I. Adnexal branches of uterine artery; arteriographic study in human subjects. *Acta radiol.*, 1953, *40*, 561–582.
5. Borell, U., and Fernström, I. Ovarian artery; arteriographic study in human subjects. *Acta radiol.*, 1954, *42*, 253–265.
6. Brink, D., and Lodeman, H. Placentography in management of placenta praevia. *Brit. M. J.*, 1958, *1*, 216.
7. de Villiers, P. D., and Brink, D. Aortography: Safest means of placental localization? Preliminary report. *South African M. J.*, 1957, *31*, 37–40; Abstr. *Radiology*, 1957, *69*, 780.
8. dos Santos, R., Lamas, A. C., and Caldas, J. P. Artériographie des membres et de l'aorte abdominale. Masson & Cie, Paris, 1931.
9. Fernström, I. Arteriography of uterine artery. Its value in diagnosis of uterine fibromyomata, tubal pregnancy, adnexal tumour, and placental site localization in cases of intra-uterine pregnancy. *Acta radiol.*, 1955, Suppl. 122.
10. Gaylis, H., and Laws, J. W. Dissection of aorta as complication of translumbar aortography. *Brit. M. J.*, 1956, *2*, 1141–1146.
11. Hartnett, L. J. Possible significance of arterial visualization in diagnosis of placenta previa. *Am. J. Obst. & Gynec.*, 1948, *55*, 940–952.
12. Hodge, K. E. Gravitational placentography. *Radiology*, 1957, *68*, 637–647.
13. Lentino, W., and Lentino, N. New manually-controlled pressure injector for angiocardiography, retrograde aortography and selective angiocardiography. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1957, *77*, 343–346.
14. McAfee, J. G., and Willson, J. K. V. Review of complications of translumbar aortography. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1956, *75*, 956–970.
15. McAfee, J. G. Survey of complications of abdominal aortography. *Radiology*, 1957, *68*, 825–838.
16. Muller, R. F., and Figley, M. M. Arteries of abdomen, pelvis and thigh. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1957, *77*, 296–311.
17. Norman, O. III. Localisation of placenta by means of arteriography and auscultation. *Brit. J. Radiol.*, 1953, *26*, 393–401.
18. Seldinger, S. I. Catheter replacement of needle in percutaneous arteriography; new technique. *Acta radiol.*, 1953, *39*, 368–376.
19. Sutton, D. Placental and pelvic angiography by retrograde percutaneous injection of femoral artery. *Brit. J. Radiol.*, 1952, *25*, 320–325.

THE ROENTGENOLOGIC INTERPRETATION AND USES OF PERCUTANEOUS RETROGRADE PELVIC ARTERIOGRAPHY*

By BILLY P. SAMMONS, LT. M.C., JOHN R. WILLIAMS, LT. M.C., CHARLES GARTENLAUB, CAPT. M.C., RICHARD L. BERNSTINE, LT. M.C., JAMES H. NELSON, JR., LT. M.C., *and* ROBERT B. GREEMAN, CAPT. M.C.

ST. ALBANS, LONG ISLAND, NEW YORK

INJECTION techniques for studying the uterine and ovarian arteries in the cadaver were first utilized by Luschke in 1863. Similar studies by Freund in 1904 and Kelly and Cullen in 1909 were climaxed by the classic paper of Sampson[27] in 1912. The latter author illustrated the normal and myomatous uterus by conventional stereoscopic reproductions of 100 post-operative uteri injected with colored and radiopaque materials. His observations of the normal uterine arterial supply, the uninjectable myometrial zone, and the increased vascularity with a relative lack of veins within the substance of myomata have been confirmed by such later *in vitro* studies as Faulkner's[15] in 1944.

Not until 1930 did interest in pelvic arteriography of the living subject become evident judging from the pioneer work of Saito and Kamikawa. These workers described a method of retrograde injection of the femoral artery for the roentgenologic examination of the pelvic arteries. The following year using aortography dos Santos and co-workers[10] described the uterine artery in 6 cases, 1 of which was six months pregnant. From this meager number of cases they noted the increased vascularity of fibromyomas as opposed to ovarian cysts and described the placental sinuses. In 1935 Coutts *et al.*[8] visualized the placenta in all of their 12 patients near term examined by translumbar aortography. Fariñas,[11] in 1941, did retrograde aortography and demonstrated displacement of the pelvic vessels produced by a large uterine tumor. With the advent of the war the lack of rubber catheters resulted in his employing a retrograde catheterization of the femoral artery after direct exposure.[12,13]

The problem of diagnosis in placenta previa was attacked in 1948 by Hartnett[18] employing translumbar aortography. Remarkably enough, his only complication in 68 patients was the induction of labor in many of those near term.

The next advance was in 1952 when Borell *et al.*[3] reported 100 obstetric and gynecologic patients examined by percutaneous retrograde iliac arteriography. Their observations on the blood supply of pelvic tumors, intrauterine pregnancies, and tubal pregnancies were by far the most complete to that time. Since then further contributions to the study of these problems have been made by such investigators as Guilhelm, Smith, Sutton, Norman, Spanio, and Fernström.

TECHNIQUE

Although the early delineation of the uterine arteries was by translumbar aortography and the latest reported series[17] by the catheter technique of Seldinger,[28] we believe the percutaneous retrograde femoral artery approach to be safer, simpler, more comfortable for the patient, and as reliable. In an occasional patient the opposite femoral artery must be injected if needed for comparison or if the arterial supply to an area may unexpectedly be from the opposite side. Since in 80 per cent of the cases the opposite uterine artery from the injected femoral artery is also opacified, the desirability of catheterization seems even less indicated.

After excluding known drug idiosyn-

* Radiological and Obstetrical and Gynecological Departments, St. Albans Naval Hospital, St. Albans, Long Island, New York. The opinions expressed are those of the authors and do not necessarily reflect the views of the Navy Medical Department.

crasies and severe peripheral vascular disease, the correct menstrual time is determined by the objectives of the examination. All elective gynecologic examinations should be performed immediately before, during, or after menstruation to fill the greatest number of intramural vessels and to avoid the uninjectable inner myometrial zone.

Nothing by mouth for six hours, a low cleansing enema, and demerol one hour before the examination constitute the preoperative instructions. The urinary bladder is emptied for the comfort of the patient only, since whether the projection of the uterine vessels is improved or worsened is unpredictable.

The patient is placed supine, bilateral tourniquets are placed above the origin of the deep femorals, the inguinal area prepared and cleansed with zephiran, and a sterile eye sheet laid over the area. With gloved fingers the femoral artery is palpated and its course marked on the overlying skin. Zylcaine is injected immediately inferior to the inguinal ligament, care being taken to infiltrate the tissues in juxtaposition to the femoral artery. After inserting a 15 gauge needle through the skin to prevent any binding, the operator inserts a Lindeman needle 20 degrees cephalad down to the artery. The sharp inner needle then transfixes the artery which has previously been immobilized by a finger applying pressure on both sides of the artery. The needle with the surrounding cannula is then inserted, and since the opposite wall is often pierced, the needle is slowly withdrawn until pulsating blood is seen and then quickly threaded up the artery approximately 1 cm. The sharp inner needle is then removed leaving the smooth cannula. A saline filled disposable plastic tube with a 30 cc. syringe is then attached to the needle stopcock. While watching the pulsation of blood in the clear tubing, the cannula is clipped to the skin employing a rubber-shod small towel clamp. After forcefully injecting the saline, a test dose of the contrast material is injected and five minutes allowed to elapse before proceeding. The patient is then reminded of the fleeting abdominal discomfort and of the Valsalva maneuver with the injection to slow the systemic circulation. The pressure cuffs are inflated well above the systolic pressure and 20 cc. in obstetric and 30 cc. in gynecologic patients then injected as rapidly as possible. The tourniquets are released immediately on cessation of the film exposures.

The films for pregnancies consist of one 14 by 17 inch roentgenogram in the anteroposterior projection exposed three seconds after the end of the injection; if the placenta is seen to be lying low, a second injection after a ten minute delay is performed to obtain a lateral roentgenogram for more precise localization. The bladder must be emptied before this repeat injection. For gynecologic problems the pelvis is centered over a serialograph, the tube angled 15 degrees caudad, and 6 films exposed at one second intervals beginning halfway through the injection. Again the bladder should be emptied before a second injection to prevent obscuration of the pelvic arterial detail.

Miokon 50 per cent was originally chosen as the contrast medium because of the lack of spasm in the urinary tree visualized on intravenous pyelography, suggesting a minimal irritation of the epithelium. In view of the oscillometric findings in Table 1 which compare favorably with similar studies,[29] the absence of

Table I

Case No.	Oscillometric Findings			
	Before Injection		After Injection	
	Injected Leg	Opposite Leg	Injected Leg	Opposite Leg
1	12–18	13–17	11–18	11–16
2	10–17	12–16	8–15	13–19
3	9–14	10–18	11–16	8–13
4	13–20	12–16	10–15	13–20
5	12–18	11–17	12–18	12–17
6	12–20	10–16	10–13	10–16

Note: The initial slight decrease in oscillations was followed by a moderate increase as the diluted contrast material recirculated.

uterine arterial spasm seen on the second injection by other workers in one-third of their cases[17] and the minimal pain of short duration when an extravasation occurs, it seems that miokon is an excellent contrast material for this procedure.

After no more than two injections, the needle is withdrawn, firm digital pressure maintained over the puncture site for ten minutes and the patient kept in bed for two hours.

COMPLICATIONS

There has not been a serious complication in this series of 85 patients which includes 45 pregnant women in all trimesters. Fleeting lower abdominal pain during the injection has not been a problem as regards blurring due to motion. Nausea was noted in less than 10 per cent. Extravasation of 30 cc. in 1 patient required no additional analgesia or zylcaine infiltration and rapid roentgenographic clearing was noted. The examination was repeated uneventfully two days later. In the pregnant patients neither contractions nor labor were initiated and there was no evidence of harm to the fetuses since delivered. The experience of other workers is summarized in Table II to point out the absence of complications with retrograde methods as opposed to the experience in aortography. It should be noted that with the technique described no contrast material ascends farther than the bifurcation of the aorta so that renal, spinal cord, and visceral vascular complications are avoided.

ROENTGEN FINDINGS

In the adult female pelvis the simple fetal arrangement of the uterine artery supplying the uterus and the ovarian artery supplying the ovary is occasionally not retained. Following descent of the ovary, the anastomotic channels between these vessels become increasingly better established so that rarely the ovarian artery may supply the uterus and adnexa. This fact explains the uncommon nonvisualization of the uterine artery with a completely opacified iliac artery.

The origin, course, and branches of the uterine artery are diagrammatically illustrated in Figure 1. Only if this normal distribution is firmly in mind can variations be of diagnostic significance. Especially in interpretation of the pelvic arteries, which normally vary with uterine position, phase of the menstrual cycle, parity and the usual arterial variations of supply must strict

TABLE II

Author and Year		Technique		Serious Complications		Comment
		Aorta	Femoral	Maternal	Fetal	
dos Santos	1931	6		0	0	1 case 6 mo. pregnant
Coutts	1935	12		1 death	0	meningeal hemorrhage
Fariñas	1946		?	0	0	
Hartnett	1948	68		labor induced in several	0	labor induced mostly near term
Kunlin	1950	3		0	0	
Borell	1952		101	0	0	21 pregnant
Guilhelm	1952	1		0	0	pregnancy near term
Smith	1952	5		0	0	pregnancies near term
Sutton	1952	3		0	0	pregnancies near term
Borell	1953		300	0	0	includes 1952 cases
Norman	1953		25	0	0	all pregnant
Spanio	1954	12		0	0	all 5–9 mo. pregnant
Borell	1954	77		0	0	
Fernström	1956		550	0	0	includes cases of Borell

criteria for abnormal variations be determined. For this reason the entities which have readily recognizable abnormal vascular patterns are listed in Table III. In addition to the notes of caution listed, the following pitfalls deserve mention: (1) Large numbers of intramural vessels may be visualized especially premenstrually which, if superimposed, may resemble second month placental sinuses. It is for this reason that the diagnosis of an intrauterine pregnancy cannot be made with certainty before the third month, while irregular vascular lakes outside of the uterus make a diagnosis of ectopic pregnancy possible in the second month. The relation of the placental site to intramural uterine vessels may be more accurately determined by filling both uterine arteries, and, in addition, if the placenta visualizes from both unilateral femoral injections, the intrauterine position is proved. (2) In addition to the menstrual variation, hormones can produce marked widening of the uterine arteries without affecting the other pelvic arteries.[4] (3) During the second injection some contrast media cause the uterine artery to narrow markedly, obscuring valuable signs.

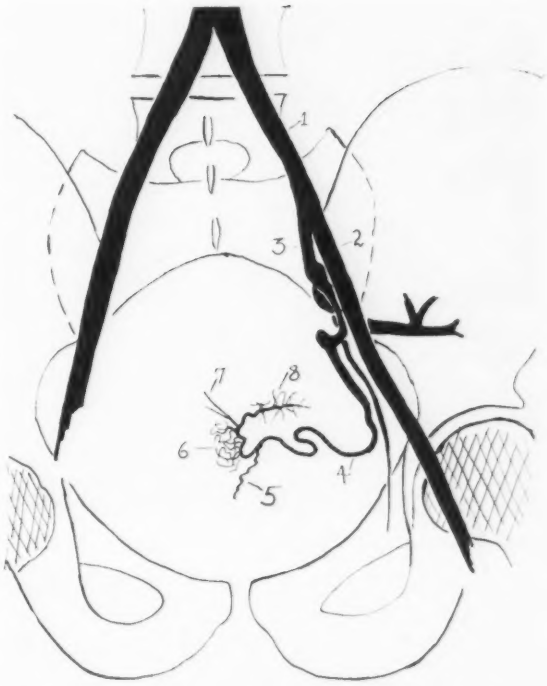


FIG. 1. Schematic diagram of the normal female arterial supply to the uterus and adnexa: 1—common iliac artery; 2—external iliac artery; 3—hypogastric artery; 4—uterine artery; 5—cervical branch of the uterine artery; 6—convoluted branches to the uterine wall; 7—fundal branch of the uterine artery; 8—adnexal branches of the uterine artery.

TABLE III

Condition	Abnormality of the Pelvic Vasculature
Intrauterine Pregnancy	1. Placental sinuses visualize after the second month 2. Marked increase in tortuosity and width of the intramural vessels leading to the placental site 3. Uterine artery along the uterine wall loses its tortuosity and the width increases 4. Visualization of layering of the veins beneath the placental site
Tubal Pregnancy	1. Placental sinuses may be identified by the end of second month 2. Tubal branches of the uterine artery become dilated, lose their tortuosity, and become arched 3. The above two signs are excellent, if observed; however, their absence does not suggest a diagnosis by exclusion since the detachment of the placenta or blood supply by the ovarian artery may be the reason for nonvisualization
Fibromyomata	1. Intramural uterine vessels lose their tortuosity adjacent to the tumor Note: the fundal branch is normally straight 2. The uterine artery is increased in width
Adnexal Tumors	1. The adnexal branches of the uterine artery are arched and straightened 2. An increased vascularity of the solid tumors is noted

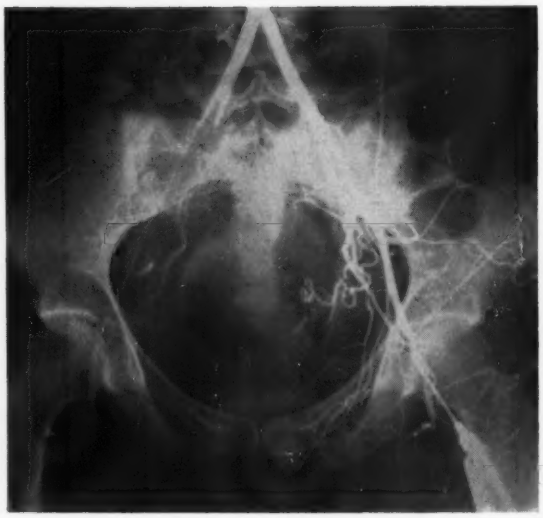


Fig. 2. Normal retrograde femoral arteriogram demonstrating the opacification of the opposite iliac artery and a normally tortuous uterine artery.

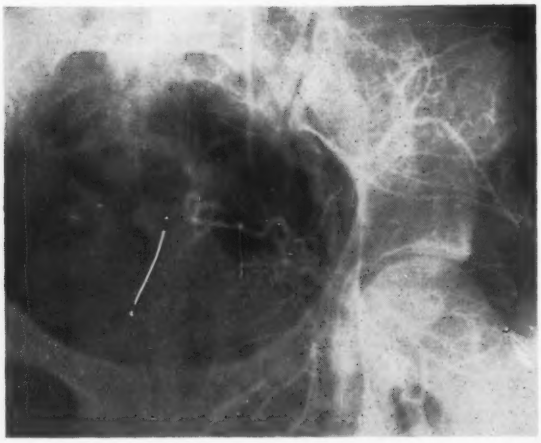


Fig. 3. A left hydrosalpinx straightened the left uterine artery. Note the adnexal and vaginal branches which are normal. Surgical confirmation.

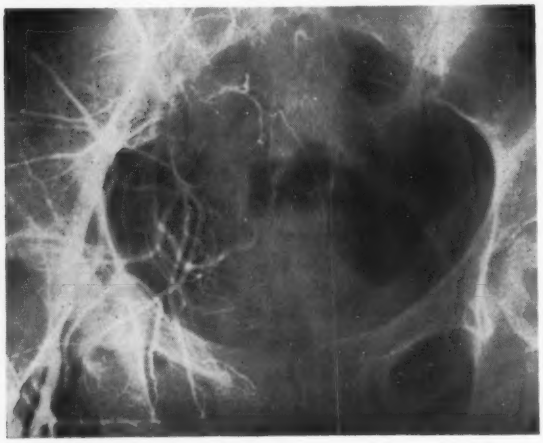


Fig. 4. At surgery a large serous cystadenoma was found which straightened and displaced inferiorly the right uterine artery.

Fig. 5. Two weeks post partum the markedly elongated, dilated, and tortuous uterine artery is visualized. These findings do not quite revert to the primiparous state; therefore, the loss of tortuosity in a multipara is of greater significance than in a primipara.

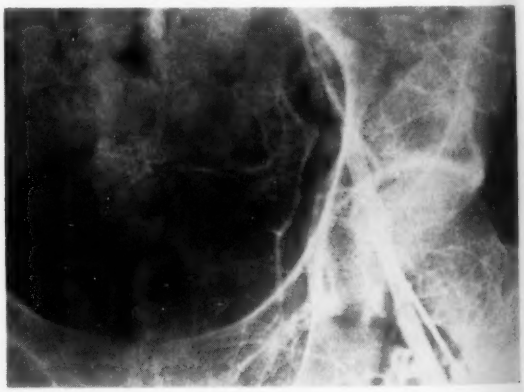


Fig. 6. The postmenopausal straightening and decrease in the caliber of the uterine artery is strikingly illustrated in this fifty-eight year old multipara.

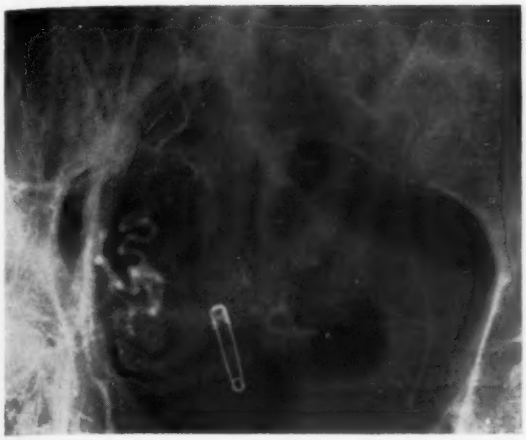


FIG. 7. At surgery a 6 cm. in diameter left tubal pregnancy was found. This explains the straight left uterine artery and the markedly displaced and crowded right uterine artery from the displaced uterus. The placental sinusoids were not visualized since with rupture the maternal arterial supply was no longer perfusing the placental site.

DISCUSSION

As in general medical and surgical problems, angiographic techniques have provided clearer anatomic and functional information in obstetric and gynecologic cases. This type of examination is justified initially after meticulous planning in an attempt to gain new knowledge for better patient care. We feel that retrograde femoral arteriography has proved itself worthy of a permanent place as a diagnostic procedure, but should not be used unless the following conditions are met: (1) simpler, safer, and less expensive procedures have failed to give the information necessary for the management of the case and (2) when the results of the examination can reasonably be expected to have a bearing on the choice between radical and conservative therapy.

FIG. 8. A normal placenta with the mottled appearance of the sinusoids is clearly visualized above the equatorial plane of the nine month pregnant uterus.

FIG. 9. Following a severe hemorrhage a femoral arteriogram revealed placental sinusoids deep within the pelvis. The interpretation of partial placenta previa was confirmed by pelvic examination in the operating room.

One of the most valuable uses of this procedure is in suspected cases of placenta previa after soft tissue roentgenography has failed to give conclusive results. Other techniques such as stereoscopy, contrast examination of the bladder and/or rectum, amniography, and most meticulously exposed soft tissue studies are either far too hazardous or are unreliable when needed most. Familiar examples are abortions in amniography, dangerous radioactive elements retained in the body after placentography with thorium dioxide, and false results with soft tissue techniques especially in early pregnancies, oblique and trans-

Fig. 10. (*A*) During the fifth month of pregnancy a profuse vaginal hemorrhage suggested the diagnosis of placenta previa. Because soft tissue placentography is of no value at this developmental age, a retrograde femoral arteriogram was obtained. Note the tortuous uterine arteries located primarily below the equatorial plane of the uterus. (*B*) Lateral roentgenogram exposed at three seconds after injection demonstrates the placenta occupying the lower uterus, confirming the diagnosis of total placenta previa.

verse lies, and in some breech presentations. Placenta previa accounts for about 5 per cent of all maternal deaths associated with delivery, and, though the outcome may be less tragic, it is often most critical and hectic. This risk is largely obviated by early diagnosis and adequate therapy, but since most, if not all deaths follow internal examination, the following indications for arteriography seem justified: (1) hemorrhage during pregnancy however slight not explained by inspection of the cervix or soft tissue roentgenography and (2) a fetal head unaccountably high with regard to the pelvic brim which cannot be made to engage by gentle external pressure. Another practical advantage is being able to immediately determine whether hospitalization, prolonged bed rest, or delay in pelvic examination is warranted. Again it should be emphasized that if the anteroposterior projection demonstrates a low lying placenta, a second injection to obtain a lateral roentgenogram will give more accurate information as regards the relation of the margin of the placenta to the cervical os.

In tubal pregnancy the procedure is especially valuable if the usual pregnancy tests are negative in view of a strong clinical impression. The fact that clinical difficulty from ectopic pregnancy is unusual before the sixth week largely removes the disadvantage of the arteriogram remaining normal until that time.

In uterine fibromyomata pelvic arteriog-

raphy can often distinguish between an adnexal tumor and this more benign tumor when the bimanual examination is equivocal. The determination of the cause of uterine bleeding when other methods have failed can often be facilitated by the study of the uterine myometrial vasculature for otherwise undetectable fibromyomata.

In our limited number of cases of salpingitis, we have been unable to assign any diagnostic significance to the pelvic vascular pattern. Except for the exclusion of a uterine origin, the study of ovarian tumors has also proved unrewarding. This is not in complete agreement with some previous reports.[2,16]

Additional avenues of investigation by this technique that hold promise are in the management of suspected and proved cases of hydatidiform moles and chorionepithelioma.[6] The behavior of the uterine vessels in hypermenorrhea should be studied employing this technique.

SUMMARY

The history, technique, roentgenographic findings, and complications of retrograde pelvic arteriography have been briefly discussed. The contraindications and uses have been stressed and illustrated to demonstrate the value of this relatively simple diagnostic procedure.

Billy P. Sammons, Lt.(MC)
United States Naval Hospital
St. Albans 25, Long Island, New York

REFERENCES

1. BALL, R. P., and GOLDEN, R. Roentgenologic sign for detection of placenta previa. *Am. J. Obst. & Gynec.*, 1941, *42*, 530–533.
2. BORELL, U., and FERNSTRÖM, I. Adnexal branches of uterine artery; arteriographic study in human subjects. *Acta radiol.*, 1953, *40*, 561–582.
3. BORELL, U., FERNSTRÖM, I., LINDBLOM, K., and WESTMAN, A. Diagnostic value of arteriography of iliac artery in gynaecology and obstetrics. *Acta radiol.*, 1952, *38*, 247–263.
4. BORELL, U., FERNSTRÖM, I., and WESTMAN, A. Hormonal influence on uterine arteries; arteriographic study in the human. *Acta obst. et gynec. scandinav.*, 1953, *32*, 271–284.
5. BORELL, U., FERNSTRÖM, I., and WESTMAN, A. Diagnostic value of percutaneous retrograde arteriography of iliac artery in cases of tubal pregnancy. *West. J. Surg.*, 1953, *61*, 223.
6. BORELL, U., FERNSTRÖM, I., and WESTMAN, A. Value of pelvic arteriography in diagnosis of mole and chorionepithelioma. *Acta radiol.*, 1955, *44*, 378–384.
7. CLARK, J. G. Cause and significance of uterine hemorrhage in cases of myoma uteri. *Johns Hopkins Hosp. Bull.*, 1899, *10*, 11–20.
8. COUTTS, W. E., OPAZO, L., BANDERAS BIANCHI, T., and SANHUEZA, O. Abdominal circulation during late pregnancy as shown in aortograms. *Am. J. Obst. & Gynec.*, 1935, *29*, 566–571.
9. DOS SANTOS, R., LAMAS, A. C., and CALDAS PEREIRA, J. Arteriografia da aorta e dos vasos abdominais. *Med. contemp.*, 1929, *47*, 93–96.
10. DOS SANTOS, R., LAMAS, A. C., and CALDAS, P. J. Artériographie des membres et de l'aorte abdominale. Masson & Cie, Paris, 1931.
11. FARIÑAS, P. L. New technique for arteriographic examination of abdominal aorta and its branches. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 641–645.
12. FARIÑAS, P. L. Retrograde abdominal aortography. AM. J. ROENTGENOL. & RAD. THERAPY, 1946, *55*, 448–451.
13. FARIÑAS, P. L. Retrograde abdominal aortography. *Radiology*, 1946, *47*, 344–348.
14. FAULKNER, R. L. Injection study of uterine blood vessels. *Am. J. Obst. & Gynec.*, 1945, *49*, 1–9.
15. FAULKNER, R. L. Blood vessels of myomatous uterus. *Am. J. Obst. & Gynec.*, 1944, *47*, 185–197.
16. FERNSTRÖM, I. Arteriography of uterine artery. Its value in diagnosis of uterine fibromyomata, tubal pregnancy, adnexal tumour, and placental site localization in cases of intra-uterine pregnancy. *Acta radiol.*, 1955, Suppl. 122.
17. FERNSTRÖM, I. Pelvic arteriography. *Acta obst. et gynec. scandinav.*, 1956, *35*, 164–180.
18. HARTNETT, L. J. Possible significance of arterial visualization in diagnosis of placenta previa; preliminary report. *Am. J. Obst. & Gynec.*, 1948, *55*, 940–952.
19. HARTNETT, L. J. Visualization of maternal circulation at site of placenta (placentagrams). *J. Missouri M. A.*, 1947, *44*, 754–756.
20. KUNLIN, J., BITRY-BOELY, C., and VOLNIE, B. Remarques sur l'aortographie. *Rev. de Chirurg.*, 1950, *69*, 286.
21. MOIR, J. C. Placentography. I. Opening address—review of placentography. *Brit. J. Radiol.*, 1953, *26*, 385–387.
22. NORMAN, O. Localisation of placenta by means of arteriography and auscultation. *Brit. J. Radiol.*, 1953, *26*, 393–401.
23. NORMAN, O. Recent advances in hysterosal-

pingography and angiography in gynaecological diagnosis. *J. Obst. & Gynaec. Brit. Emp.*, 1955, *62*, 816–819.

24. Pierce, E. C. Percutaneous femoral artery catheterization in man with special reference to aortography. *Surg., Gynec. & Obst.*, 1951, *93*, 56–74.
25. Reid, F. Radiological localisation of placenta. *Brit. J. Radiol.*, 1953, *26*, 406–412.
26. Rossi, L., and Maggipinto, B. New methods of radiological examination in gynecology; pelvic aortography and arteriography. *Ann. radiol. diag.*, 1956, *29*, 41–74.
27. Sampson, J. A. Blood supply of uterine myomata. *Surg., Gynec., & Obst.*, 1912, *14*, 215–230.
28. Seldinger, S. I. Catheter replacement of needle in percutaneous arteriography; new technique. *Acta radiol.*, 1953, *39*, 368–376.
29. Shaw, R. S. Vascular responses to intra-arterial diodrast and urokon during arteriography. *Surgery*, 1956, *39*, 385–388.

VOL. 80, NO. 4

THE PRENATAL ROENTGEN DIAGNOSIS OF FETAL HYDROPS

By EUGENE M. SAVIGNAC, M.D.
DETROIT, MICHIGAN

THE term fetal hydrops indicates the most severe form of erythroblastosis fetalis. Erythroblastosis is a condition characterized by fetal edema, jaundice, and pronounced extramedullary hematopoiesis involving chiefly the liver and the spleen, but also the other organs and tissues of the body. It usually occurs in infants born as the result of conception between a father with Rh positive blood and a mother with Rh negative blood. The Rh negative mother, however, must have been sensitized to Rh positive blood either by a previous pregnancy or by a transfusion with Rh positive blood; consequently, the first born child is not afflicted with the disease unless the mother has had such a transfusion in the past.

Ritvo, Shauffer and Krosnick[7] in 1949 gave a splendid review of the various conditions under which parents with Rh incompatibility may or may not produce offspring with erythroblastosis fetalis. They stated that from 2 to 5 per cent of children with Rh negative mothers develop the disease. They also emphasized the fact that Rh negative blood was found practically only in the Caucasian race and was most prevalent among people of the Belgian and Basque nationalities.

In recent years, however, the classic concept of the etiology of erythroblastosis fetalis has been somewhat modified. So many exceptions to the rule have been encountered that it has become practically impossible to predict whether or not erythroblastosis will occur in any given pregnancy. Numerous subgroupings of blood have been identified as responsible and numerous cases of sensitization have occurred in parents with A and O blood groups to produce erythroblastosis. The Rh factor has been shown to be a hereditary dominant factor and the frequency of sensitization of the Rh negative will depend on whether the husband is homozygous or heterozygous, following the usual mendelian hereditary ratios. Many cases of erythroblastosis fetalis have also occurred without any apparent cause.

CLINICAL CLASSIFICATION AND FEATURES

Clinically, erythroblastosis fetalis is subdivided into three types. In order of increasing severity, they are: (1) congenital anemia; (2) icterus gravis neonatorum; and (3) fetal hydrops.

Congenital anemia is the mildest and rarest form of erythroblastosis fetalis. It is characterized by marked pallor and anemia with numerous immature red blood cells in the fetal peripheral blood. It is usually self-limited and ordinarily does not require specific therapy.

Icterus gravis neonatorum is by far the most common form of erythroblastosis fetalis. As its name implies, it is manifested by jaundice, which as a rule appears during the first day of life but may delay its appearance for several days up to one or more weeks. Coincidentally, there is a progressive anemia with numerous nucleated red blood cells. The severe cases die with pulmonary or intracerebral hemorrhages, but most cases are cured by exchange transfusions with Rh positive blood other than that of the father.

These two types ordinarily cannot be diagnosed roentgenographically.

Fetal hydrops, the most severe type of erythroblastosis fetalis, constitutes the subject of the present paper. It is almost universally fatal during the last trimester of pregnancy; rarely, however, the fetus is born alive only to succumb within a few hours. Fetal hydrops is chiefly manifested by severe generalized edema of the subcutaneous tissues and internal organs of

the fetus, and also by a severe edema of the placenta. Boyd[2] states that normally the placenta is one-sixth or one-fifth the size and weight of the fetus while in fetal hydrops the fetus and the placenta are almost equal in weight and volume. In reviewing the recent roentgenologic literature, this tremendous increase in the dimensions of the placenta has not been emphasized, yet the enlarged placenta constitutes an integral feature of the disease. In dealing with fetal hydrops, the French authors have used a term which describes the gross pathology much more accurately; they call the disease "fetoplacental anasarca," thus impressing upon the mind the fact that the placenta participates in the edema equally with the fetus.

In addition, the hydropic fetus is usually stillborn, weighs more than the usual fetus of a similar state of maturity because of its dropsical condition, ordinarily shows enlargement of the liver and spleen, and immature erythrocytes are present in the peripheral blood.

ROENTGEN FEATURES

The first account of fetal hydrops in the roentgenologic literature was Hellman and Irving's[4] article published in 1938. They described 3 cases, 2 of which they diagnosed in utero on the basis of the "halo sign," a "dark ring" around the fetal skull on a roentgenogram of the mother's abdomen. They attributed this sign to edema of the scalp. Nowadays, the sign has been completely discarded because it was based on the false physical concept that edema fluid is more radiolucent than other soft tissues or amniotic fluid. It has happened in the past that the normal subcutaneous fatty tissue of the fetus has been misinterpreted as the halo sign. As a matter of fact, there is never a halo around the fetus in fetal hydrops because the subcutaneous tissue is so thoroughly infiltrated with edematous fluid that the normal fetal fat line is rendered invisible or practically so.

In 1942, Javert[5,6] reviewed 7 cases of fetal hydrops stating that he found the halo sign in only 2, while the remaining 5 cases showed roentgenographically a dense line (the opposite of Hellman and Irving's dark ring) around the fetal skull. This dense line was then called the halo sign. Boldero and Kemp[1] believe that the halo in the illustration in Javert's article was probably caused by the image of the uterine wall outlined by the extrauterine fatty tissue, which frequently has this appearance in an engaged vertex presentation. Javert proposed a roentgen sign which he considered more reliable. It referred to the attitude of the fetus in utero and was called the "Buddha sign." The fetus is described as showing a general extension of the torso and neck because the severe edema, and the enlargement of the liver and spleen, prevent the fetus from assuming its normal attitude of flexion of the spine. The extremities are held at right angles to the trunk because of the edema, while the lower ribs are splayed outwardly by the enlarged liver and spleen.

Boldero and Kemp[1] accept the Buddha sign as helpful in advanced cases of hydrops and also add that the roentgenograms show evidence of hydramnios. It appears, however, that they probably mistake the image of the tremendously enlarged placenta for hydramnios.

Ritvo, Shauffer and Krosnick[7] as well as Follis, Jackson and Carnes[3] also describe a definite increase in bone density in fetuses afflicted with erythroblastosis. This density is said to involve chiefly the occiput and the sphenoid bones of the skull, while the other cranial bones are less markedly affected. However, in normal fetuses, the sphenoid and occiput always appear more dense than other bones in the skull. The vertebrae are described as exhibiting marked sclerosis and there are varying degrees of increased density in the pelvis and long bones. Ritvo *et al.*[7] state that these changes can be seen in technically perfect roentgenograms of the mother's abdomen. The present author has not been able to detect these changes with any degree of assurance. Ritvo and Follis and their co-workers claim that the increased density of the fetal bones is also

shown on histologic sections, while Samuel and Cohen[8] were unable to confirm this fact on microscopic study of the bones of hydropic fetus when compared with the bones of a non-hydropic fetus of a similar degree of maturity. On the other hand, Samuel and Cohen have published the roentgenogram of a non-hydropic stillborn fetus in which they infiltrated the subcutaneous tissues on one side of the body with sterile water while the other side of the fetus was left intact. The bones on the infiltrated side appeared more dense than on the control side.

Thus, there appears to be a series of confusing claims and counter-claims in the literature concerning the roentgen diagnosis of fetal hydrops. The author will attempt to eliminate as much of the confusion as possible.

As in practically any other disease condition, the roentgen diagnosis will depend upon a strict adherence to the gross pathologic findings correlated to the appearance of these findings on roentgenograms.

In fetal hydrops, we are essentially faced with a dead fetus in the third trimester of pregnancy, showing a severe generalized edema, enlargement of the liver and spleen, and a pronounced enlargement of the placenta. There is no major increase in the amount of amniotic fluid as there is no room for excessive fluid in the uterine cavity which is already distended by the fetus and the large placenta.

Routinely, our roentgenologic studies of the pregnant mother consist of an anteroposterior roentgenogram of the abdomen, a heavily penetrated lateral roentgenogram of the pelvis and abdomen, and a lateral soft tissue roentgenogram of the uterus and fetus. These roentgenograms will usually show:

1. *A dead fetus in the last trimester of pregnancy* with signs of fetal death such as collapsed cranial bones and/or gas in the fetal heart and great vessels.

2. *Edema of the fetus.* Normally, the fetus shows a layer of subcutaneous fat outlining the contour of the body and extremities. Snow[9] was the first to emphasize the importance of this fetal fat line in the diagnosis of various pathologic conditions of pregnancy. The fat line on good roentgenograms can be easily recognized throughout the last three months of pregnancy. It becomes more pronounced and heavier as term approaches and in large fetuses. Of course, it can be seen only because of the greater radiolucency of fat when compared to the other soft tissues.

In fetal hydrops, the fat line becomes invisible or nearly so, because of infiltration of this fatty tissue by edema. In obese women and in hydramnios, the fat line is much less distinct but can usually be recognized on careful study since there is no infiltration of the fetal fatty subcutaneous tissue.

3. *Evidence of a large placenta.* In technically satisfactory roentgenograms, the outline of the entire uterus can be easily traced and its borders easily determined. The large placenta of fetal hydrops displaces the fetus within the uterus. Depending upon the site of implanation, the placenta causes a major shift of the entire fetus within the uterus to the right or left, frontward or backward, etc. Roentgenologically, the placenta itself casts no pathognomonic shadow. We know, however, that in hydrops the placenta is very large and consequently will occupy almost half of the volume of the uterine cavity and it must necessarily displace the fetus into the remaining free half of the uterus. Naturally, a large intrauterine tumor such as a fibroid or a large extrauterine mass could also produce such a fetal shift, but in such instances, the fetal fat line remains visible since it is not infiltrated by edema.

Furthermore, in hydramnios the placenta is of normal size and the fetus floats freely in the excessive fluid and remains centrally located within the uterus; there is no major shift of the fetus. Thus the distinction between a large placenta, intrauterine or extrauterine tumors, and hydramnios should not occasion much difficulty.

Lastly, in the differential diagnosis, abruptio placentae with a large retroplacental hematoma could produce a major shift of the fetus but here again the fetal fat line remains plainly visible.

4. *Abnormal attitude of the fetus.* This is also directly related to the fetal edema. Normally, the fetus tends to curl up into a position resembling a ball. In hydrops, however, the severe edema of the soft tissues of the anterior portion of the neck, chest and abdomen produce a straightening out of the entire trunk and the neck. The arms and legs, being swollen, are no longer flexed upon the body but tend to project at right angles to the trunk. The enlargement of the liver and spleen also causes the lower ribs to lie at right angles to the vertebral column instead of slanting downward. This has been well described by Javert[5,6] as the "Buddha sign."

In the author's experience, no conclusive evidence of increased density of the fetal skeleton can be shown on roentgenograms of the mother's abdomen.

The mother is usually a white multipara with Rh negative blood while the father is Rh positive. The first pregnancy as a rule is normal. It must be realized, however, that there are numerous exceptions to this.

REPORT OF CASES

Case I. M.C., a white thirty-six year old woman, had 3 normal living children born in 1945, 1947 and 1950. A full term stillborn was delivered in 1949 showing signs of erythroblastosis.

The present pregnancy was due to terminate on August 5, 1955. The patient was admitted to the hospital on May 9, 1955 after two weeks of vomiting and dependent edema. She also had a small sudden painless vaginal hemorrhage about three hours before admission. The mother was Rh negative and the husband Rh positive. The mother's red blood cells were agglutinated by Rh positive blood in a titer of 1 to 8. On admission, the fetal heart could not be heard. The uterus corresponded to an eight month pregnancy in size.

Anteroposterior and lateral roentgenograms of the abdomen (Fig. 1, *A* and *B*) on admission showed a large uterus containing a small fetus of five and one-half to six months' gestation. The fetus was displaced far to the left and somewhat downward and dorsally in the uterus (presumably by the enlarged placenta). Gas could be faintly seen in the fetal heart and there was no visible fetal fat line. The fetus was markedly straightened out with its arms at right angles to the body. The lower ribs were splayed.

On May 11, 1955 the patient spontaneously delivered a hydropic macerated female fetus weighing 4 pounds and 5 ounces (2,180 gm.). The placenta was markedly edematous and weighed 4 pounds and 4 ounces (2,150 gm.) (Fig. 2). There was no hydramnios.

Autospy showed a severe hydrops of all the tissues. The chest cavity contained 400 cc. of fluid and the abdomen 300 cc. The liver and spleen were not enlarged. Microscopically, all the viscera showed edema and foci of immature red blood cells. The diagnosis was hydrops fetalis.

Case II. M.S., a white woman aged thirty-one, had normal living children born in 1945 and 1951. Another child born in 1947 died nine days after birth of erythroblastosis. The mother had Rh negative blood, while the father's blood was Rh positive.

The present pregnancy was uneventful and the patient was admitted in labor on November 15, 1955, the expected date of confinement. On examination, the fetal heart sounds could not be heard.

Roentgenograms (Fig. 3, *A* and *B*) showed a fetus near term with a rather large collection of gas in the heart indicating fetal death. The fetal fat line could be faintly visualized but was not nearly as prominent as usually seen in a fetus practically at term. There was a rather large placenta on the right anterior wall of the uterus, displacing the fetus to the right and posteriorly. No abnormal attitude of the fetus was noted and there was no evidence of hydramnios.

The patient delivered spontaneously a few hours later, an extensively macerated, hydropic female child weighing 8 pounds and 5 ounces (3,830 gm.). The placenta was described as being much enlarged and edematous but was not weighed.

At autopsy, the fetus showed severe generalized edema, and a large liver and spleen. Con-

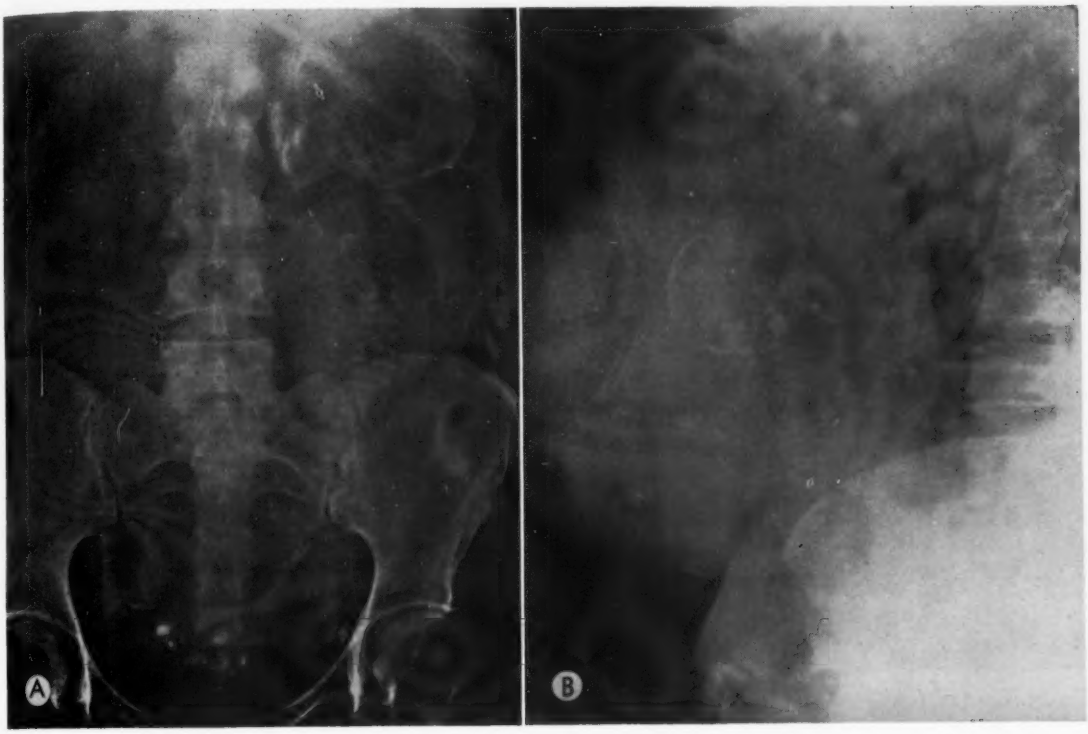


FIG. 1. Case I. (*A* and *B*) A six month fetus showing air in the fetal heart. Note the marked displacement of the fetus to the left and posteriorly by the enlarged placenta on the right anterior wall of the uterus. There is no visible fetal fat line and the fetus is straightened out.

siderable fluid was present in both the chest and abdomen. The viscera showed edema and marked infiltration with nucleated red blood cells microscopically.

CASE III. P.N., a white twenty-six year old woman, had one living child following the first pregnancy. Three subsequent pregnancies resulted in one miscarriage at four months and two stillbirths. There was Rh incompatibility between her blood and that of her husband.

The present pregnancy was uneventful until about the thirtieth week when the mother began developing edema, nausea and rapid enlargement of the abdomen. She was admitted at about the beginning of the eighth month in mild labor. The fetal heart sounds were inaudible and the abdomen quite large.

Roentgenograms (Fig. 4, *A* and *B*) showed a fetus of eight months' gestation which was displaced dorsally within an enlarged uterus by a large placenta implanted on the anterior wall of the uterus. The fetus was decidedly straightened out and showed no visible fetal fat line. There was definite collapse of the cranial bones.

FIG. 2. Photograph showing the markedly edematous fetus and placenta, shown in Figure 1, after birth.

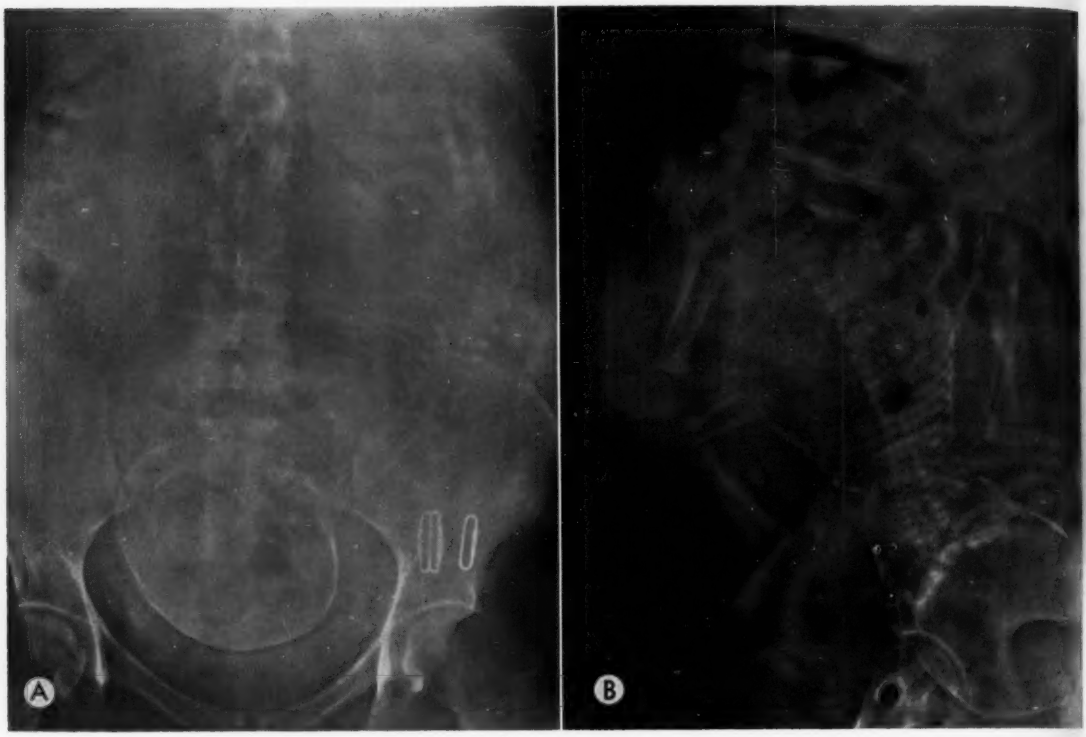


FIG. 3. Case II. (*A* and *B*) Large placenta displacing the full term fetus to the left. Note the poor fetal fat line, air in the fetal heart and collapse of the cranial bones.

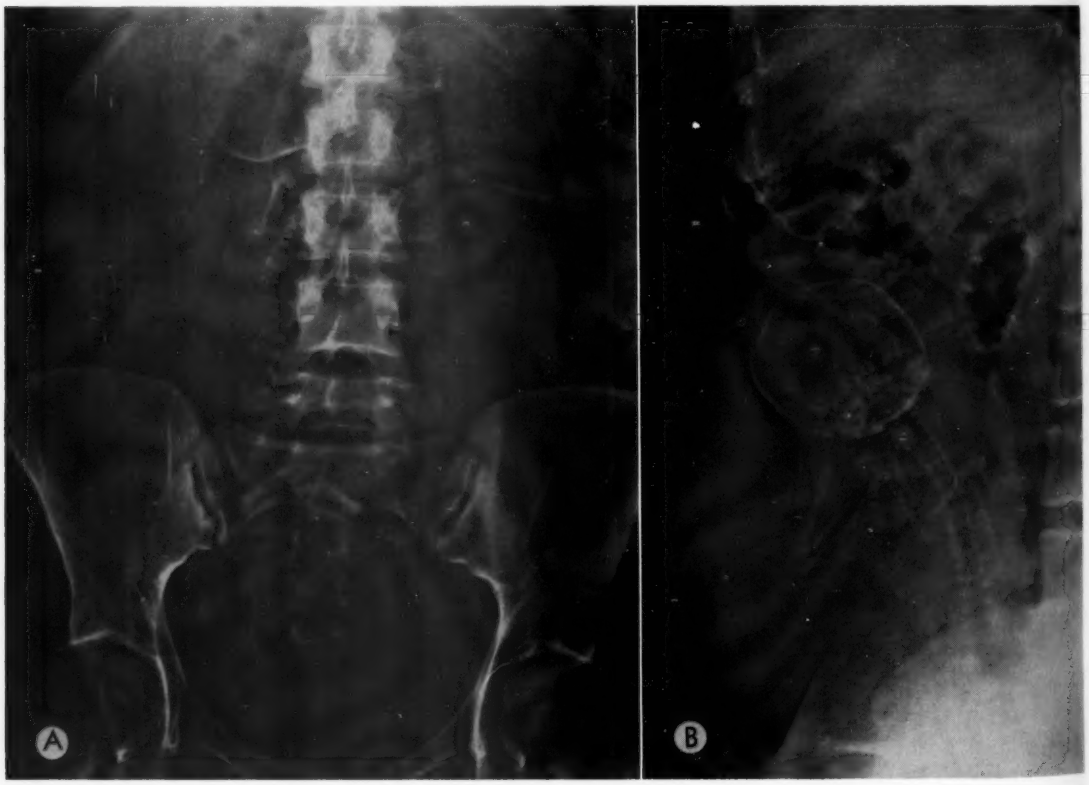


FIG. 4. Case III. (*A* and *B*) Note the dead eight month fetus displaced posteriorly by the large placenta. There is no fetal fat line and the fetus is markedly straightened out.

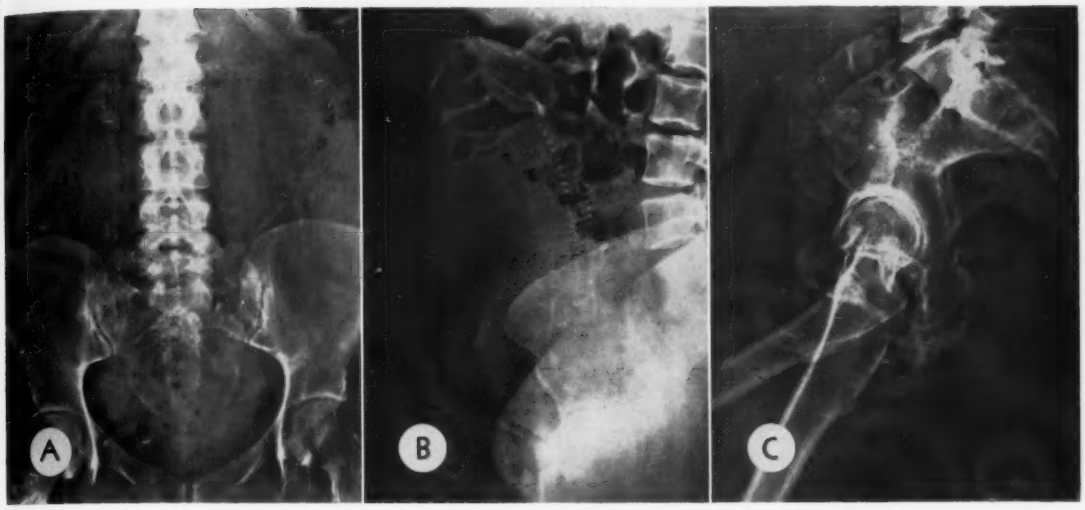


Fig. 5. Case IV. (*A*, *B* and *C*) Dead six month fetus displaced posteriorly by the large anterior placenta. No fetal fat line can be visualized. The fetus is straightened out. There are also enchondromata of the right femur and ischium of the mother.

On the day of admission (October 17, 1957) a macerated hydropic female child weighing 3 pounds and 2 ounces (1,420 gm.) was delivered by breech extraction. The placenta was not weighed but it approximated the size of the fetus and was also edematous; microscopically, it showed evidence of erythroblastosis.

Case IV. E.Q., a twenty-seven year old white female, had a normal live birth in 1954 and a full term stillborn in 1957. There was Rh incompatibility between herself and her husband.

In the present pregnancy, the estimated date of confinement was April 29, 1958 but she was admitted on January 22, 1958 following two weeks of nausea and vomiting and a sudden gain in weight of 10 pounds during the previous week. The uterus appeared much larger than a six month pregnancy and no fetal heart sounds were heard.

Roentgenograms (Fig. 5, *A*, *B* and *C*) showed a single fetus crowded into the posterior portion of the uterus by a large placenta. The fetus was markedly straightened out and showed no fetal fat line.

On the same day the patient delivered a macerated, hydropic female weighing 2 pounds and 11 ounces (1,230 gm.). The large edematous placenta weighed 3 pounds (1,360 gm.) and showed microscopic evidence of erythroblastosis. There was no hydramnios.

SUMMARY

1. A review of the salient clinical features of fetal hydrops and of the roentgenologic literature is presented.

2. An attempt is made to correlate the gross pathology of fetal hydrops with the roentgen diagnosis before birth.

3. The roentgenographic manifestations of fetal hydrops consist essentially of obliteration of the fetal fat line in a dead fetus, which is found markedly displaced within the uterine cavity by a large edematous placenta. The fetal edema also produces a straightening out of the normally flexed fetus.

Holy Cross Hospital
4777 E. Outer Drive
Detroit 34, Michigan

REFERENCES

1. Boldero, J. L., and Kemp, F. H. Diagnosis of hydrops foetalis. *Brit. J. Radiol.*, 1950, *23*, 219–224.

2. Boyd, W. A Text Book of Pathology: An Introduction to Medicine. Sixth edition. Lea & Febiger, Philadelphia, 1953.

3. Follis, R. H., Jr., Jackson, D., and Carnes, W. H. Skeletal changes associated with erythroblastosis fetalis. *J. Pediat.*, 1942, *21*, 80–92.

4. Hellman, L. M., and Irving, F. C. X-ray diagnosis of erythroblastosis. *Surg., Gynec. & Obst.*, 1938, *67*, 296–298.
5. Javert, C. T. Erythroblastosis neonatorum; obstetrical-pathological study of 47 cases. *Surg., Gynec. & Obst.*, 1942, *74*, 1–9.
6. Javert, C. T. Further studies on erythroblastosis neonatorum of obstetric significance. *Am. J. Obst. & Gynec.*, 1942, *43*, 921–940.
7. Ritvo, M., Shauffer, I. A., and Krosnick, G. Clinical and roentgen manifestations of erythroblastosis fetalis. Am. J. Roentgenol. & Rad. Therapy, 1949, *61*, 291–301.
8. Samuel, E., and Cohen, J. Pre-natal radiological diagnosis of hydrops foetalis. *Brit. J. Radiol.*, 1950, *23*, 225–230.
9. Snow, W. Roentgenology in Obstetrics and Gynecology. Second edition. Charles C Thomas, Publisher, Springfield, Ill., 1952.

VOL. 80, NO. 4

DEUEL'S HALO SIGN*

By OLOV FR. HOLM
FALKÖPING, SWEDEN

AT ROENTGEN examination of relatively mature fetuses before delivery, a zone of reduced density is usually discovered around the head of the fetus, produced by the subcutaneous layer of fat. If the fetus is dead, this transparent zone in certain cases is separated from the cranium by a layer of the same density as the other soft tissues of the fetus. This finding was described for the first time by Deuel[5] in 1947 as a sign of intrauterine fetal death. His observation was based on 4 cases.

Since then, Deuel has been quoted frequently in articles dealing with roentgenologic signs of intrauterine death of the fetus; however, very few authors have given a description of this finding based upon their own observations.

From October, 1953 to January, 1958 inclusive, I have made systematic roentgenologic examinations of all women treated at the obstetrical department of Länslasarettet, Falköping, in whom intrauterine fetal death was suspected and I have further examined all dead fetuses. These examinations were principally made with the intention of studying the frequency of and conditions causing the formation of gas in the fetuses at intrauterine death. The results obtained have been reported in a number of articles.[6–9]

The following facts can now be considered as having been established as regards the formation of gas in the dead fetus: (1) gas usually forms in the vascular system of the fetus. In certain cases it is also found outside the vascular system as, for example, in the peritoneal cavity or skull, and rarely it diffusely infiltrates the retroperitoneal tissues; (2) free gas in the fetus is a common finding in case of intrauterine death of the fetus; (3) if present, it can be demonstrated roentgenologically with a fair degree of certainty before delivery; (4) free gas often appears earlier than other roentgenologic signs of intrauterine death of the fetus; (5) frequently, free gas in the fetus is the only roentgenologic sign of intrauterine death; and (6) the only factors which appear to have a positive bearing on the formation of gas are the degree of maceration and the maturity of the fetus. The more advanced both of these factors, the greater the formation of gas.

MATERIAL AND RESULTS OF STUDY

The present material comprises 64 dead fetuses, of which 40 had been examined before as well as after delivery. Deuel's halo sign was observed in 9 instances. Several authors earlier considered this finding to be unusual; however, in 1957 Borell and Fernström,[2] in a published report of 42 cases of intrauterine death of the fetus, described Deuel's halo sign in 14 cases, indicating that the finding is more common than was formerly supposed.

The incidence of the various roentgenologic signs of intrauterine fetal death observed in the author's material is given in Table 1. As may be seen, in several of the cases more than one sign of death of the fetus had been present. At least one sign was demonstrated in 31 cases, enabling a roentgenologic diagnosis of intrauterine death in more than 75 per cent.

The degree of maceration was evaluated according to the grading of Martius *et al.*[11] which is as follows: Degree I. The epidermis is loose or detached in small areas. This occurs a few hours after fetal death. Degree II. The skin is raised by large blisters and can be easily scaled off in big flakes. In this case the death of the fetus has taken place one to three days previously. Degree III. Hemolysis and inbibition of the tissues with blood pigment cause the fetus

* From the Department of Radiology (Director: Olov Fr. Holm) Länslasarettet, Falköping, Sweden.

Table I

INCIDENCE OF ROENTGENOLOGIC SIGNS OF INTRAUTERINE FETAL DEATH DEMONSTRATED PRIOR TO DELIVERY

Signs of Intrauterine Fetal Deaths	No. of Cases	No. with Single Sign
A. Head		
1. Spalding's sign	9	1
2. Deformity of skull	7	—
3. Deuel's sign	9	3
B. Trunk	8	5
C. Gas in Fetus	19	8

Table II

DEGREE OF MACERATION AND NUMBER OF CASES PRESENTING DEUEL'S HALO SIGN AND FREE GAS

Degree of Maceration	No. of Cases	Presenting Deuel's Sign	Presenting Free Gas
I	3	1	0
II	14	1	8
III	23	7	11
Total	40	9	19

to become red-brown in color (fetus sanguinolentis). The bone connections become loose and the cranium is soft and fluctuating. Generally, this occurs three to four weeks after death.

Table II shows the degree of maceration and the number of cases presenting Deuel's halo sign and free gas in the author's series. It may be noted that both signs occurred more frequently when the maceration was more advanced, although as a whole they were observed earlier than other signs of intrauterine fetal death. In 8 cases, roentgenologic demonstration of free gas made possible the diagnosis within three days after the death of the fetus and

Fig. 1. Living fetus. The subcutaneous layer of fat around the head of the fetus is situated in direct contact with the cranium of the fetus.

Fig. 2. A fetus which had been dead for a period of seven days. The subcutaneous layer of fat appears as a transparent zone similar to a halo and is separated from the cranium by a layer 3 mm. in width and of the same density as the other soft tissues of the fetus.

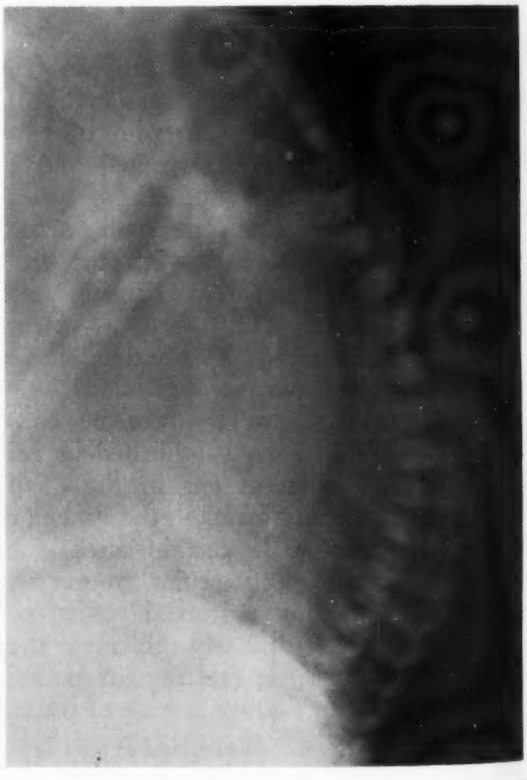


Fig. 3. A fetus which had been dead for a period of ten days. There is evidence of a great amount of gas in the abdominal aorta.

occasionally within twenty-four hours. Deuel's sign in one case had been present for a period of twenty-four hours, after which the fetus was considered to be dead.

The author[9] has shown earlier that the formation of gas in the fetus is in direct proportion to the degree of the maturity of the fetuses at death. This was based on a study of a number of dead fetuses. As regards Deuel's sign, its frequency also increases as maturity advances. This is probably due to the fact that the subcutaneous layer of fat is hardly seen in small fetuses. The roentgenologic sign of fetal death principally noted at this time is maceration of the trunk. The fetuses exhibiting formation of gas had an average length of 50 cm. and an average weight of 2,760 gm. The corresponding figures were 50 cm. and 2,580 gm., respectively, for the fetuses with the Deuel halo sign, and 44 cm. and 1,750 gm., respectively, for the fetuses with maceration of the trunk.

CONCLUSION

1. Intrauterine fetal death can be determined in the majority of cases (>75 per cent) by means of a roentgenologic examination.

2. Free gas is the most common and the most important sign of fetal death.

3. Deuel's halo sign is not an unusual finding and is encountered as often as Spalding's sign.

4. In cases where the death of the fetus occurs when the fetus is almost at term, free gas and Deuel's halo sign are frequently noted, whereas when the fetus dies in an early stage of development, the most common roentgenologic sign of death is the maceration of the trunk.

Department of Radiology
Länslasarettet
Falköping, Sweden

REFERENCES

1. BILLING, L. Über die Bedeutung des röntgenographischen Übereinanderschiebens der Schädelknochen des Fötus. *Acta radiol.*, 1941, *22*, 277–280.
2. BORELL, U., and FERNSTRÖM, I. Value of "halo sign" in diagnosis of intra-uterine foetal death. *Acta radiol.*, 1957, *48*, 401–409.
3. CRICK, A. F., and SIMS, F. H. Gas within foetus indicating foetal death. *J. Fac. Radiologists*, 1953, *5*, 126–133.
4. DAVIDSON, C. N. Roentgen demonstration of fetal death (gas within fetus) and uterine rupture; report of three unusual cases. AM. J. ROENTGENOL. & RAD. THERAPY, 1949, *62*, 837–842.
5. DEUEL, H. Zur Röntgendiagnose des intrauterinen Fruchttodes. *Schweiz. med. Wchnschr.*, 1947, *77*, 1003–1005.
6. HOLM, O. F. Free gas in fetal vessels as roentgenologic sign of intra-uterine fetal death. *Acta radiol.*, 1954, *42*, 116–120.
7. HOLM, O. F. Occurrence of free gas in fetus in cases of intra-uterine death. *Acta radiol.*, 1956, *45*, 257–265.
8. HOLM, O. F. Roentgenological signs of intrauterine foetal death. *Acta obst. et gynec. scandinav.*, 1957, *36*, 58–74.
9. HOLM, O. F. Factors contributing to formation of gas in fetus in cases of intra-uterine death. *Acta radiol.*, 1957, *48*, 257–266.
10. MARGOLIS, A. J., and JONES, M. D. Gas within circulation of dead fetus in utero; report of 2 cases. *Obst. & Gynec.*, 1954, *3*, 631–636.
11. MARTIUS, H., BICKENBACH, W., and DROYSEN, K. Lehrbuch der Geburtshilfe. Second edition. Georg Thieme Verlag, Stuttgart, 1952.
12. ROBERTS, J. B. Gas in fetal circulatory system as sign of intrauterine fetal death. AM. J. ROENTGENOL. & RAD. THERAPY, 1944, *51*, 631–634.
13. SAMUEL, E., and GUNN, K. Gas embolus as roentgen sign of fetal death. AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED., 1955, *73*, 974–978.
14. SPALDING, A. B. Pathognomonic sign of intrauterine death. *Surg., Gynec. & Obst.*, 1922, *34*, 754–757.
15. STEWART, A. M. Importance of radiographic demonstration of free gas in foetus in diagnosis of intra-uterine death. *J. Obst. & Gynaec. Brit. Emp.*, 1957, *64*, 915–920.
16. TAGER, S. N. New roentgen sign of fetal death. AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED., 1952, *67*, 106–110.
17. WICKLUND, H. Presence of free gas in fetal circulatory system as pathognomonic sign of intra-uterine death. *Acta Soc. med. Upsal.*, 1957, *62*, 104–112.

TRAUMATIC RUPTURE OF THE GRAVID UTERUS

By C. E. PARKINSON, M.D.
BATTLE CREEK, MICHIGAN

RUPTURE of the gravid uterus incident to the forces of labor is a catastrophic obstetric emergency of sufficient frequency to be well described and quickly recognized. However, rupture of the gravid uterus as a result of external violence and trauma is a relatively rare and seldom reported event.

The gravid uterus, with its membranes and surrounding fluid, is a highly efficient shock-absorber. Even severe pelvic fractures may be experienced without apparent damage to the uterus or its contained fetus.

The uterus, however, can be ruptured by external violence. Two factors, the increasing incidence of major motor vehicle accidents and the present high birth rate, produce a situation in which traumatically ruptured gravid uteri must be considered in evaluating seriously injured women.

The following brief case report illustrates the value of roentgenographic examination in recognizing this phenomenon.

FIG. 1. Roentgenogram reveals an intact bladder and a fetal skeleton of approximately five months' gestation, lying transversely in the abdomen, well out of the pelvis. A diagnosis of uterine rupture with extrusion of the fetus into the peritoneal cavity was suggested.

REPORT OF A CASE

An eighteen year old divorced white woman, gravida II, para I (by classic cesarean section), was admitted to the emergency room unconscious and in deep shock following a major automobile crash. Rapid examination indicated severe head injury with fractured skull, shock and fractures of the appendages and ribs. Blood pressure was unobtainable.

Immediate plasma followed by 2,500 cc. of whole blood and other therapy stabilized the blood picture and shock in twenty-four hours. Unconsciousness persisted some eighteen hours. Blood was noted on the perineum and a catheterized urine specimen was packed with red blood cells. Consequently, a bed-side cystogram was obtained utilizing portable roentgen-ray equipment. This examination (Fig. 1) revealed an intact bladder and also a fetal skeleton of approximately five months' gestation. The fetus was lying transversely in the abdomen, well out of the pelvis, and with the skeleton showing no constricting influence of a surrounding uterus. The examination indicated probable uterine rupture with extrusion of the fetus into the peritoneal cavity.

The patient's precarious condition, due to her head injuries, was thought to contraindicate abdominal surgery in view of her satisfactory response to transfusions.

Sixteen days after the accident her condition permitted more detailed roentgenographic examination. The original diagnosis was confirmed by this study (Fig. 2).

Twenty-four days after the accident laparotomy was performed. A five to five and a half month fetus was removed from the peritoneal cavity in a macerated condition. Multiple fragments of placenta were found attached to the mesenteries and bowel wall. A large ragged rent was found in the fundus of the uterus and most of the uterine body was disintegrated and necrotic. A total hysterectomy was performed

FIG. 2. Roentgenogram made sixteen days after accident confirming the diagnosis.

without difficulty. The patient recovered with surprising rapidity and left the hospital seven days after surgery.

DISCUSSION

It is of interest that without emergency surgical intervention, this traumatic rupture of a gravid uterus produced a degree of hemorrhage satisfactorily compensated by transfusions.

Titus[1] describes a phenomenon of "Silent Rupture of the Pregnant Uterus" occurring spontaneously before the onset of labor, and producing less of a crisis than rupture associated with labor. He postulates that in these instances rupture occurs in the thin, less vascular, more contractile portion of the uterus. Even if the fetus and membranes are extruded from the uterus, hemorrhage may be relatively slight due to the rapid contraction of the uterus. It is likely that a similar mechanism operated in our case with the force of violence being directed toward the fundus rather than toward the vascular and less contractile lower segment as occurs in labor.

The roentgenographic findings in this case resemble those reported by Zuppinger:[2]

1. A fetus lying high in the pelvis or in the abdomen.
2. A fetal position demonstrating no adjustment to a surrounding envelope of uterine muscle.
3. An absence of a demonstrable uterine shadow.
4. Evidence of free fluid in the peritoneal cavity.

SUMMARY

1. Rupture of the gravid uterus must be considered in women suffering major trauma.

2. Roentgenographic examination is of great value in making the diagnosis.

3. A case is briefly described in which (a) the roentgenographic findings permitted diagnosis and (b) hemorrhage was controlled without emergency surgery.

Route 3, Box 605
Battle Creek, Michigan

REFERENCES

1. TITUS, P. The Management of Obstetrical Difficulties. C. V. Mosby Company, St. Louis, 1946, p. 547.
2. ZUPPINGER, A. Roentgen Diagnostics in Obstetrics. In: Schinz, H. R., Baensch, W. E., Friedl, F., and Uehlinger, E. Roentgen-Diagnostics. Volume IV. English translation arranged and edited by James T. Case. Grune & Stratton, Inc., New York, 1954, p. 3933.

GARTNER'S DUCT

By JOSEPH F. WEPFER, M.D.,* *and* JOHN E. SINSKY, M.D.†
MILWAUKEE, WISCONSIN

IN 1952 Bianchi, Äppli and Wilk[2] described an unusual and interesting finding on hysterosalpingography. Within the uterine wall they found a linear shadow filled with contrast medium which extended from the region of the cervix to the cornu. Recently, we observed the same structure and, in agreement with the above authors, attributed it to the presence of a persistent Gartner's duct. To our knowledge this finding has not been reported in the American literature.

In our case (Fig. 1) the patient was being investigated because of repeated spontaneous abortions. Except for filling of the duct, which is shown to advantage in the right posterior oblique view (Fig. 2 and 3), the roentgenographic findings were normal. Physical examination was not contributory. We reviewed 312 hysterosalpingograms after encountering our case and were unable to find another instance in which the duct opacified.

Pathogenesis can most advantageously be discussed after a brief consideration of the pertinent embryologic factors.

FIG. 1. Anteroposterior roentgenogram illustrating a segment of Gartner's duct adjacent to the uterine cavity on the left. Note residual barium in the colon.

FIG. 2. Right posterior oblique roentgenogram. The duct is more clearly delineated and is shown extending from the region of the cervix to the cornu uteri.

EMBRYOLOGY[1]

The urinary and reproductive systems arise from mesoderm and are closely allied during the course of development. The intimacy and complexity of these developmental relationships are thoroughly described by Gruenwald.[5]

Three different types of urinary organs are found in vertebrates (Fig. 4). The simplest is the pronephros which consists of tubules and an excretory duct ending in the cloaca. It functions only in a few lower forms. Fish and amphibians are served by a somewhat more complex excretory organ, the mesonephros. This structure contains a greater number of tubules and retains the pronephric duct which at this stage of development is known as the mesonephric or Wolffian duct. The final and most complex organ of excretion, the metanephros, is found in reptiles, birds and mammals.

* Department of Radiology, St. Joseph's Hospital, Milwaukee, Wisconsin.
† Department of Obstetrics and Gynecology, St. Joseph's Hospital, Milwaukee, Wisconsin.

Fig. 3. Enlargement of area of interest in Figure 2.

In the human the pronephros appears as a vestigial structure. The mesonephros, or middle kidney, is a fairly well developed unit. The tubules and the greater portion of the mesonephric duct degenerate in the female. That portion which persists is known as Gartner's duct. Remnants of it may be located in the broad ligament, in the wall of the uterus or in the wall of the vagina (Fig. 5). Gartner's duct cysts are one of the commonly encountered benign vaginal tumors.[6] The cysts are usually found on the anterolateral wall and vary in size and number. Although generally small, a cyst may occasionally become so large that the vagina can no longer accommodate it. In the male, portions of the mesonephric duct are utilized as functional sexual ducts.

The female genital organs are derived from the two Müllerian ducts. The caudal ends fuse to form the uterus and possibly the proximal portion of the vagina. Various anomalies of the female genital tract result from incomplete transformation of the Müllerian ducts. In the male these ducts largely degenerate. The few remnants which persist are without clinical significance (appendix testis, prostatic utricle).

DISCUSSION

Bianchi *et al.* found 11 examples of this type of opacified duct among a total of 660 hysterosalpingograms. In their material the duct was found 4 times on the right and 7 on the left side. Bilateral filling did not occur. In 9 instances an associated salpingitis was observed and it was their opinion that the presence of Gartner's duct predisposes to this condition.

Microscopic remnants of Gartner's duct are said to be found in about one-fourth of all adult females.[1] Sakuraoka[7] reported its presence in about 20 per cent of all Japanese women above the age of seventeen. His microscopic studies of the uterus and vagina indicated that the ductal remnants

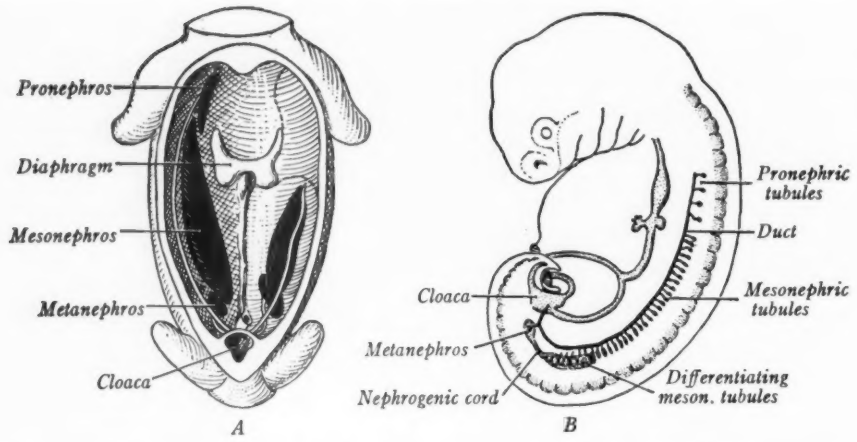


Fig. 4. Location and relations of the three kidney types in mammals (semidiagrammatic). (*A*) Ventral dissection, the left side showing a later stage than the right. (*B*) Lateral view, with nephric system and gut showing through. (Reproduced by permission from "Developmental Anatomy" by L. B. Arey. W. B. Saunders Company, Philadelphia and London, 1954.)

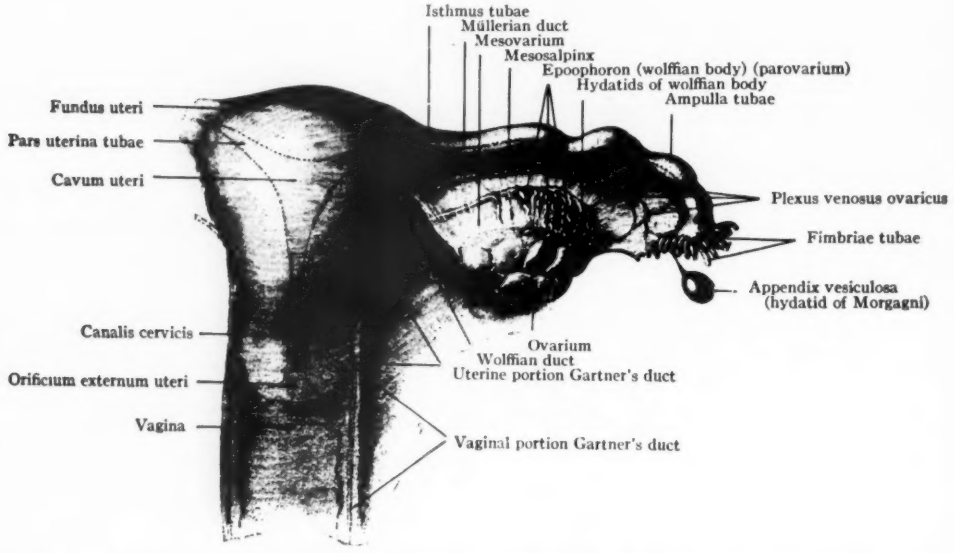


Fig. 5. Relations of the Müllerian, Wolffian and Gartner's ducts to the uterus and adnexa. Gartner's duct is the inferior continuation of the Wolffian duct. (After Cullen in Callander: Surgical Anatomy, third edition. W. B. Saunders Company, Philadelphia and London, 1952.)

occurred with greater frequency on the left side. These remnants were discovered to be bilateral four times. He also observed that the duct was frequently either tortuous or divided at the level of the internal os. On occasion it is believed one of these branches may communicate with the lumen of the uterus and account for instances of abnormality of the urinary tract in which a ureter ends in the uterus, cervix or vagina.[3,5] The ureter, of course, arises from an outpouching of the lower end of the mesonephric duct.

The possibility that the linear shadow is derived from one of the Müllerian ducts must be carefully considered. If this were

true, one might reason that there ought to be coexisting uterine abnormalities or at least some uterine asymmetry. Reference to Gruenwald's work, however, indicates that this type of data is difficult to interpret inasmuch as abnormalities of the urinary and genital tracts may be associated. The original authors found an associated uterus arcuatus and several hypoplastic uteri and recommended looking for concurrent anomalies in the presence of an opacified duct. In our material we found a number of congenital uterine abnormalities and numerous examples of tubal occlusion but in none of these instances was the duct opacified.

Consideration of urinary tract abnormalities also has not contributed significantly to the solution of this issue. In neither the original article nor in our study were urinary tract alterations observed. Pyelography was not performed in our patient but no renal abnormalities were noted on a postevacuation roentgenogram following an examination of the colon.

Bianchi *et al.* felt that a definite decision as to the histogenetic origin of the structure could only be made on microscopic analysis. Gardner *et al.*[4] have stated that they are able to differentiate those structures of mesonephric origin from those of paramesonephric (Müllerian) origin. As far as we know, a duct which has been demonstrated on roentgenograms has never been studied histologically.

CONCLUSIONS

1. Gartner's duct may be opacified during hysterosalpingography.

2. A single case with roentgenographic findings is reported. A review of 312 other hysterosalpingograms yielded no further instances in which the duct was opacified.

Joseph F. Wepfer, M.D.
St. Joseph's Hospital
5000 W. Chambers Street
Milwaukee 10, Wisconsin

REFERENCES

1. Arey, L. B. Developmental Anatomy. Sixth edition. W. B. Saunders Company, Philadelphia, 1954.
2. Bianchi, G., Äppli, H., and Wilk, S. Gartnersche Gänge; Häufigheit und klinische Bedeutung. *Radiol. clin.*, 1952, *21*, 359–362.
3. Eckerbom, H., and Liliequist B. Ectopic ureter; report of case. *Acta radiol.*, 1952, *38*, 420–427.
4. Gardner, G. H., Greene, R. R., and Peckham, B. M. Normal and cystic structures of the broad ligament. *Am. J. Obst. & Gynec.*, 1948, *55*, 917–937.
5. Gruenwald, P. Relation of growing Müllerian duct to Wolffian duct and its importance for the genesis of malformations. *Anat. Rec.*, 1941, *81*, 1–19.
6. Novak, E. Gynecologic and Obstetric Pathology with Clinical and Endocrine Relations. Third edition. W. B. Saunders Company, Philadelphia, 1952.
7. Sakuraoka, J. I. Über den Ductus epoophori longitudinalis (Gartneri) bei japanischen weiblichen Individuen. *Mitt. ü. allg. Path. u. path. Anat.*, 1937, *9*, 179–194.

REDUCTION OF RADIATION HAZARD IN OBSTETRIC ROENTGENOGRAPHY*

By WALTER M. WHITEHOUSE, M.D., CHARLES S. SIMONS, PH.D., *and* TOMMY N. EVANS, M.D.
ANN ARBOR, MICHIGAN

ONE of the byproducts of the age of atomic energy is the extension of rapid dissemination of scientific information to the scientific community and to the lay public as well. Part of this information and much of its emphasis has been concerned with hazards of exposure to excessive radiation. Data concerning radiation-induced genetic damage in experimental animals have received widespread attention. Much publicity has attended recommendations of various committees to limit the use of medical roentgenography in patients prior to and during their reproductive years.[1,5] Attention has been called to the possible increase in the incidence of leukemia and other neoplasms during infancy and childhood in patients previously exposed *in utero* to diagnostic obstetric roentgenography.[9]

Because both mother and fetus are included in antepartum roentgenography, it is doubly important that all available measures be taken to reduce exposure to radiation during these examinations. Obstetric consultants and their patients must be assured that every effort is thus made to conserve the somatic and genetic health of both mother and child.

The potential effects of excessive exposure to roentgen radiation on current and future generations add a note of urgency to attempts to reduce this hazard. This necessitates a broad attack on the problem utilizing every feasible approach. The important points of attack can be indicated as follows: (1) Use of roentgenography only for sound clinical indication; (2) standardization and simplification of roentgenographic methods; (3) adequate aluminum filtration at tube aperture with supplementary brass wedge filter; (4) use of recently available fast film; and (5) use of fast screens, with faster screens to be employed as they become available.

In view of the necessity of limiting the exposure of these patients to diagnostic radiation, routine roentgen pelvimetry for primiparous patients is no longer justified. Roentgen examination during pregnancy should be reserved for those cases in which roentgenograms will provide information essential to the solution of a major obstetric problem. A sampling of cases coming to obstetric roentgenography under this criterion over a five year period reveals the following clinical indications:

I. Investigation of possible cephalopelvic disproportion.
   A. Ante partum.
      1. Small pelvis by manual measurement.
      2. Breech presentation in primigravida at term.
      3. Failure of presenting part to engage in primigravida.
      4. Previous injury to maternal pelvis.
      5. History of previous difficult labors.
   B. Intra partum.
      1. Failure of labor to progress normally.

II. Determination of fetal maturity.
   A. Repeat cesarean section.
   B. Pre-term induction of labor for erythroblastosis fetalis.
   C. Pre-term induction or section for maternal diabetes.
   D. Induction for toxemia.

III. Determination of fetal position when clinical findings are inconclusive or suggest abnormal position.

* From the Departments of Radiology, and Obstetrics and Gynecology, University Hospital, Ann Arbor, Michigan.
This material was presented in exhibit form at the Fifty-eighth Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 1–4, 1957.

IV. Determination of placental localization in cases with bleeding during late pregnancy.
V. Investigation of excessive uterine enlargement.
  A. Multiple pregnancy.
  B. Hydramnios.
  C. Molar pregnancy.
  D. Error in menstrual history.
VI. Confirmation of fetal death or investigation of suspected fetal anomaly.

When good clinical judgment is exercised in calling for appropriate roentgen examination, the essential data are obtained in sufficient time for satisfactory solution of the clinical problem. Omission of routine roentgen pelvimetry for primiparous patients does not increase the ultimate obstetric risk if a thorough clinical evaluation is carried out with close observation of the patient during labor. Obstetric roentgenography, then, should not be employed routinely but only when necessary to provide an answer to a specific and significant clinical question.

ROENTGENOGRAPHIC METHODS

The object of obstetric roentgenography is to provide information otherwise unobtainable to the clinician; he may then correlate it with clinical findings and arrive at an appropriate plan of management of the obstetric problem.

The previous use of multiple special views and elaborate methods of measurement to provide an exhaustive independent roentgen study of the fetus and maternal pelvis must be reviewed in light of the necessity for limiting exposure to radiation. All obstetric roentgenographic methods must be critically re-evaluated; only those techniques which yield the most useful information with a minimum of radiation exposure should be selected for continued use. In our opinion, any method requiring two exposures in one projection (*e.g.*, stereoscopic methods, differential divergent double exposure methods) should be discarded. Similarly, any method bringing fetal gonads dangerously close to the tube (*e.g.*, sitting inlet view) should be abandoned.[2,4,6] Any view which merely duplicates the clinician's information (*e.g.*, special outlet, subpubic arch views) may be reserved for infrequent use in special cases.

Diagnostic detail providing critical information applicable to the great majority of clinical obstetric problems is found in a three film combination as follows: (1) Anteroposterior projection of maternal abdomen and pelvis with ischial tuberosities at lower edge of 14×17 inch film. (2) Lateral projection of abdomen with upper margin of uterus included at upper edge of 14×17 inch film. The use of a brass wedge filter over half of the tube aperture improves the diagnostic detail in the region of the anterior uterine wall[8] and further reduces the exposure dose to the patient. (3) Lateral projection of the pelvis exposed on a 10×12 inch film with an appropriate diaphragm to limit the beam. The brass wedge filter also improves the diagnostic detail anteriorly in this exposure. Basic information for obstetric diagnostic problems and for the planning of the management of labor can be obtained from this set of films for all of the frequently encountered indications.[3]

PHYSICAL FACTORS IN ACHIEVING EXPOSURE REDUCTION

I. *Aluminum Filtration.* The use of 2.5 mm. Al added filtration as recommended in the National Bureau of Standards Handbook 60[7] instead of the usual 0.5 mm. Al added filtration will reduce the skin dose of the patient by a factor of 50 per cent. The additional thickness of aluminum serves to absorb softer components of the beam that are otherwise absorbed in the superficial tissue and which do not contribute to exposure of the film. The added filter does not require any change of kilovoltage or milliampere seconds.

II. *Brass Wedge Filtration.* In making a roentgenogram in the supine lateral projection of the abdomen and pelvis, a supplementary brass wedge filter is inserted into the beam to reduce exposure anteriorly while permitting unobstructed pas-

sage of the beam penetrating the spine and posterior pelvis. The original use of the wedge[8] was to improve diagnostic soft tissue detail, but an important byproduct is the reduction of radiation exposure to the anterior abdominal wall and to fetal parts situated anteriorly. The brass wedge measures $2\frac{1}{2} \times 1\frac{3}{8}$ inches and is $\frac{1}{8}$ inch thick at its greatest thickness, tapering to a knife edge midway across the tube aperture. The wedge is placed parallel and adjacent to the aluminum filter and to the lead beam-defining diaphragm. This is removed for the anteroposterior projection of the abdomen.

III. *Fast Screens.* The use of Patterson Hi-speed screens instead of the previously used Patterson Par-speed screens has reduced the required milliampere seconds to 60 per cent. Thus the exposure dose is reduced by the same amount. With high kilovoltage technique, this reduction could be somewhat further improved. Attention has been called by Ter-Pogossian[10] to the advantages of potential increase in speed with the use of alkali halides for intensifying screens. Should these prove to be satisfactory and commercially available, their advantages in obstetric roentgenography would require their immediate adoption.

IV. *Film.* The use of higher speed roentgenographic film recently placed on the market has permitted an exposure dose reduction by a factor of 50 per cent. With the same kilovoltage settings as previously used, the milliampere seconds required to produce a roentgenogram of similar quality is 50 per cent or less of that required with previously used films.

In order to compute the reduction of the exposure dose to the patient achieved by adopting the techniques indicated above, one must multiply the reduction factors employed. Thus 50 per cent (Al filter) multiplied by 60 per cent (fast screens) multiplied by 50 per cent (fast film) yields an over-all reduction factor of 0.15. This means that the exposure to the surface of the patient will be only 15 per cent of that received prior to the institution of these three modifications. The effect of the brass filter is not computed since it is not used in the anteroposterior projection; it affords, however, further reduction in the other projections. It must not be inferred that the dose delivered to the deeper tissues is reduced by exactly the same factor of 0.15. The intervening tissue serves to "harden" a poorly filtered beam to such an extent that at a depth of from 7 to 10 cm. almost the same amount of radiation would be received by the gonads with the use of either the 0.5 mm. Al filter or the 2.5 mm. Al filter. Thus from the standpoint of the gonadal dose alone, the reduction factor becomes about 0.3.

For roentgenograms obtained in a typical obstetric case, the factors shown below are used with a Hodges pelvimetry table, focal-film distance 36 inches. The skin dose with present techniques is compared in Table 1 to the range of values found with older techniques.

ILLUSTRATIVE CASES

Case 1 (Fig. 1, *A*, *B* and *C*). D.K., 860-579. Twenty-three year old para 2, gravida 3. First pregnancy was normal. Second pregnancy resulted in delivery of stillborn erythroblastotic infant. At the time of the roentgenographic examination the patient was in thirty-seventh week of gestation.

Indication for Roentgen Examination. Determination of fetal maturity prior to pre-term induction for erythroblastosis.

Roentgen Findings. Single fetus in deflexed position with brow to right and posterior. Placenta anterior and faintly calcified. Prominent subcutaneous fat line and distal femoral epiphysis indicate fetal maturity (thirty-six to forty weeks). Cephalopelvic disproportion unless deflexed position is corrected.

Clinical Management and Outcome. Medical induction of labor was attempted and was unsuccessful. Cesarean section was then done because of deflexed position and to achieve preterm delivery. Single loop of cord around neck. Survival of living infant after exchange transfusion.

Case 11 (Fig. 2, *A*, *B* and *C*). C.H., 869-763. Thirty year old para 2, gravida 6. Patient had two normal term pregnancies and three spontaneous abortions. She was referred to Women's

Table I

Projection	Film Size, inch	Body Thickness, cm.	Added Al Filter, mm.	Brass Filter	kvp.	mas.	TSD, cm.	Skin Dose	
								Present mr	Previous mr
1. Antero-posterior abdomen	14×17	29	2.5	No	79	75	56	800	5,300
2. Lateral abdomen	14×17	31	2.5	Yes	77	150	55	1,500	10,000
3. Lateral pelvis	10×12	35	2.5	Yes	83	200	55	2,600	17,000

Calculation of gonadal dose with present techniques is as follows:

Projection	Maternal Left Ovary			Maternal Right Ovary			Fetal Gonads		
	Per Cent Depth Dose	Skin Dose mr	Dose mr	Per Cent Depth Dose	Skin Dose mr	Dose mr	Per Cent Depth Dose	Skin Dose mr	Dose mr
1. Antero-posterior abdomen	10	800	80	10	800	80	10	800	80
2. Lateral abdomen	30	1,500	450	0.8	1,500	12	5	1,500	75
3. Lateral pelvis	Lead diaphragm used; gonads at least 10 cm. outside of radiation field								
Total Dose			530			92			155

Note: Per cent depth dose based on phantom measurements at depth estimated by obstetrician corresponding to the location of maternal and fetal gonads.

Hospital because of absence of fetal heart tones for a period of two weeks.

Indication for Roentgen Examination. Confirmation of fetal death.

Roentgen Findings. Single fetus in occiput right posterior position. Prominent fetal subcutaneous fat line (1) and distal femoral epiphyses (2) indicate fetal maturity. Placenta (3)

Fig. 1. Case 1. (*A*, *B* and *C*) Single fetus in deflexed position with brow to right and posterior. Placenta anterior and faintly calcified. Prominent subcutaneous fat line and distal femoral epiphysis indicate fetal maturity. Cephalopelvic disproportion unless deflexed position is corrected.

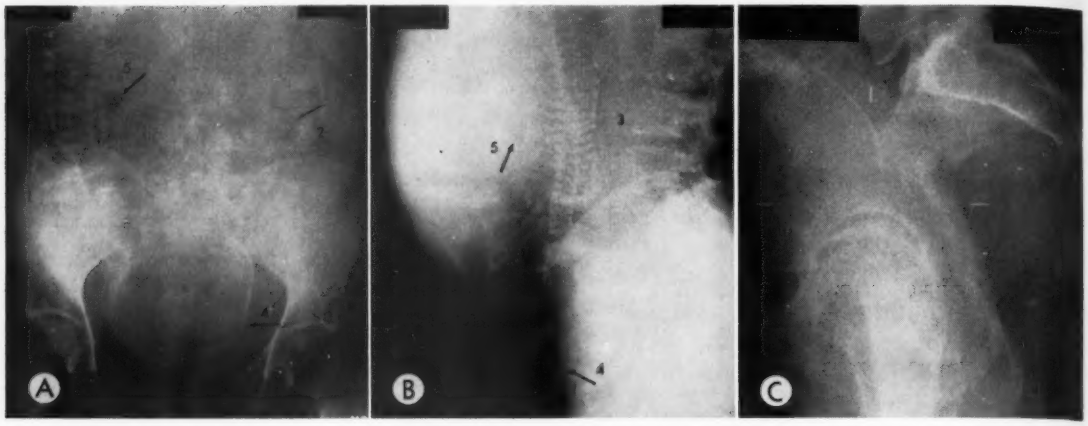


Fig. 2. Case 11. (*A*, *B* and *C*) Single fetus in occiput right posterior position. Prominent fetal subcutaneous fat line (1) and distal femoral epiphyses (2) indicate fetal maturity. Placenta (3) situated posteriorly. Spalding's sign present (4) with overlapping of skull bones. Gas in fetal heart (5) as further evidence of fetal death.

situated posteriorly. Spalding's sign present (4) with overlapping of skull bones. Gas in fetal heart (5) as further evidence of fetal death.

Clinical Management and Outcome. The patient was allowed to go into labor spontaneously three days after the roentgenograms were made. A stillborn infant was delivered with a tight true knot present in the umbilical cord, apparently the cause of death.

SUMMARY

1. All available measures should be taken to reduce exposure to radiation during obstetric roentgenography in order to protect the somatic and genetic health of both mother and child.

2. Obstetric roentgenography should not be done routinely but only for significant clinical indication.

3. All existing obstetric roentgenographic methods should be further reviewed with respect to their exposure hazard.

4. A simplified roentgenographic method consisting of three exposures yields information adequate for most obstetric problems.

5. Added aluminum filtration of 2.5 mm. in thickness should be used to reduce skin dosage. Supplementary brass wedge filtration further reduces exposure and gives improved diagnostic detail.

6. Reduction in the exposure dose by 50 per cent is achieved by using fast film.

7. Further reduction in exposure to 60 per cent is achieved by replacing Par-speed screens with Hi-speed screens.

8. Development of faster screens is anticipated and these should be employed in obstetric roentgenography when available.

9. The use of light localizers or appropriate diaphragms limits the exposure to the areas desired and thus reduces unnecessary exposure.

10. By combining the techniques indicated above, it is possible to eliminate approximately 85 per cent of the previous skin dose to the maternal patient and approximately 70 per cent of the dose previously given at the level of the maternal and fetal gonads.

11. Quantitative determinations indicate a dosage in the neighborhood of 0.5 r to the maternal ovaries and 0.15 r to the fetal gonads for the complete obstetric examination indicated above.

12. Because of the nature of its problems, obstetric roentgenography should continue to get priority in practical application of further measures to reduce radiation hazard as these measures are developed.

Walter M. Whitehouse, M.D.
Department of Radiology
University Hospital
Ann Arbor, Michigan

REFERENCES

1. Biological effects of atomic radiation. Summary report from a study by the National Academy of Sciences. National Research Council, Washington, 1956.
2. Clayton, C. G., Farmer, F. T., and Warrick, C. K. Radiation doses to foetal and maternal gonads in obstetric radiography during late pregnancy. *Brit. J. Radiol.*, 1957, *30*, 291–294.
3. Haas, R. L., Latourette, H. B., and Whitehouse, W. M. Clinical applications of obstetric radiology. *Surg., Gynec. & Obst.*, 1954, *99*, 462–468.
4. Hartley, J. B. Letter on "Radiation hazards." *Lancet*, 1956, *2*, 46.
5. Laughlin, J. S., and Pullman, I. Gonadal dose produced by medical use of x-rays; genetically significant radiation received by population of United States. National Academy of Sciences, National Research Council. March, 1957.
6. Moir, J. C. Letter on "Radiation hazards." *Lancet*, 1956, *2*, 99.
7. National Bureau of Standards. Handbook 60. Washington, Dec. 1, 1955.
8. Reeves, R. J., and Cahoon, J. B. Lateral radiography of pregnant uterus; technical review. *M. Radiog. & Photog.*, 1952, *28*, 2–10.
9. Stewart, A., Webb, J., Giles, D., and Hewitt, D. Malignant disease in childhood and diagnostic irradiation in utero. Preliminary communication. *Lancet*, 1956, *2*, 447.
10. Ter-Pogossian, M. Alkali halides x-ray intensifying screens. To be published.

AN EVALUATION OF THE SOMATIC AND GENETIC HAZARDS OF THE MEDICAL USES OF RADIATION*

By HENRY S. KAPLAN, M.D.†
SAN FRANCISCO, CALIFORNIA

Diagnostic radiology owes a great deal to Dr. Russell Carman, whose classic contributions to gastrointestinal roentgen diagnosis remain as sound today as when they were first so brilliantly elucidated. It is, therefore, fitting that radiological societies should commemorate him, and I am deeply conscious of the great honor which was rendered me in inviting me to give this lecture in his memory.

PUBLIC concern and confusion stemming from the recent extensive publicity regarding purported hazards of the medical uses of radiation make a discussion of this subject timely. Our willingness to take a fresh look at the subject does not, however, reflect any previous unawareness of this problem amongst radiologists. Indeed, the one aspect of the recent press accounts which radiologists are most justifiably prone to resent is the impression which some of these articles convey that the problem of radiation hazards has been neglected by the radiological profession in the past. Quite the contrary is true. The United States Advisory Committee on Radiation Protection was organized under the auspices of the National Bureau of Standards as early as 1929 and its Handbook 15 on x-ray protection appeared in 1931. This National Committee and its counterparts in other countries, as well as the International Commission on Radiological Protection, have functioned effectively since that time to formulate, revise, and disseminate information on radiation protection throughout the medical profession and more recently to industry as well. As a result of their efforts, roentgen-ray equipment has been re-designed to provide a great many safeguards against excessive radiation exposure to the patient and the physician, and maximal permissible dose levels have been revised downward to take account of the increasing fraction of the population engaged in occupations involving actual or potential radiation exposures.[24] The current introduction of image amplifiers represents a further significant step, stimulated by radiologists, toward the reduction of exposure during fluoroscopy. In these and in many other ways, the radiologist has traditionally taken the initiative in setting a very good example for the health professions as a whole.

Nonetheless, reports during the past two years, emanating from such responsible sources as the National Academy of Sciences of the United States,[3] and the Medical Research Council in England,[11] as well as other publications by individual authors, have suggested that certain specific types of deleterious effects might be far more significant at quite low dose levels than has generally been appreciated. I will refer in particular to recent evidence bearing on the hazards of leukemia induction, of life-shortening, and of disturbance in human population genetics. Since each of these is a vast subject in itself, I shall be forced to omit or to mention only in passing certain more familiar types of radiation injury which occur at quite high dose levels and which are therefore not of special concern in the range of the maximal permissible dose. Moreover, since a great deal of statistical data is to be found in the various recent publications on the subject, I will not resort to any dreary recitation of numbers, except where absolutely necessary to document particular points. Instead, I should like to discuss the validity of the

* Carman Lecture, Greater St. Louis Society of Radiologists, St. Louis, Missouri, October 15, 1957.
† Professor of Radiology, Department of Radiology, Stanford University School of Medicine, San Francisco, California.

evidence as it now stands, and to attempt to place these hazards in some over-all rational perspective.

SOMATIC HAZARDS

Let us first turn our attention to the somatic hazards, and the dose levels at which they are presumed to occur. Over the past several years, several distinct lines of evidence have implicated radiation in the induction of human leukemia.

LEUKEMIA

The most conclusive evidence comes from the studies of the Atomic Bomb Casualty Commission[9,18,23] in survivors of the atomic bombings at Hiroshima and Nagasaki. These data bring out a quite convincing relationship between dose, crudely reflected in distance from the hypocenter of the bomb explosion, and leukemia incidence. It is of some interest that most of the observed leukemias have been either of the chronic myelogenous or acute varieties, with almost no instancesof chronic lymphatic leukemia. However, it appears that chronic lymphatic leukemia is also surprisingly rare among the control Japanese population, a finding which in itself is a most interesting by-product of their investigation. Another point of interest is that the latent period between the time of exposure and appearance of the first wave of leukemias was only a few years, appreciably shorter than the very long latent periods observed in most of the early radiation martyrs.

Let us turn next to the second line of evidence, namely the obituary compilations by March,[21] Ulrich,[33] and others suggesting that radiologists suffer an enhanced frequency of leukemia. The total number of cases available for analysis in these reports is extremely small, and the findings are more plausible than compelling. Moreover, it seems most likely that many of the reported cases of leukemia occurred in early pioneers who were exposed to dose levels which no longer obtain in the field of radiology. I know of absolutely no evidence that exposure to the maximal permissible dose over a working lifetime of some forty years can induce leukemia. Indeed, the numbers of leukemias to be expected on the basis of even the more extreme estimates of the hazard are so small that it would be virtually impossible to detect a significant response among the relatively small total number of radiologists in the country. The question of the leukemogenic hazards of radiation at maximal permissible dose levels will have to be settled, if ever, in the much larger population newly provided by workers in the nuclear industries.

Turning from leukemias induced by atomic bomb radiation, which we fervently hope will not happen again, and leukemias induced by excessive occupational exposure, which has now been effectively eliminated, we come to leukemias attributed to diagnostic or therapeutic procedures in patients. There are three main lines of evidence here,* of which the data of Court-Brown and Doll,[8] regarding the enhanced leukemia incidence in rheumatoid spondylitis patients, are clearly the most convincing. Although dose to the spinal marrow seemed linearly related to incidence, with no threshold, the relationship to integral dose was exponential, and a threshold could not be excluded. The doses and fields of exposure used in England for the treatment of this condition were considerably larger than those which have generally been used in this country. Nonetheless, it seems prudent to conclude that radiation therapy for rheumatoid spondylitis and for other benign, chronic, recurring illnesses should be used sparingly and reserved for cases that prove refractory to other forms of treatment.

The data of Simpson and Hempelmann[29] on leukemia and thyroid cancer appearing later in life in infants treated for thymic enlargement leave something to be desired

* There have also been recent isolated case reports[1,5,26,28] of leukemia occurring in patients treated with large doses of radioiodine for hyperthyroidism or thyroid cancer. Statistical proof that these instances were indeed secondary to radiation, rather than coincidental, will require careful retrospective surveys of large numbers of cases treated some years ago.

from a statistical point of view, since the number of leukemia cases was very small, and the appropriateness of the controls is necessarily open to question. Moreover, there is no good indication of any relationship between dose and leukemia incidence, as was the case in the rheumatoid spondylitis series. Similar studies are now in progress on a larger scale and may help to establish this point more clearly. Meanwhile, however, the question is rapidly becoming purely academic, since most radiologists have long since ceased to believe that the normal large thymus of infancy does indeed produce respiratory embarrassment and have therefore ceased to recommend or administer radiation therapy for the purpose of shrinking the thymus. Since the question of leukemia induction by thymic irradiation is still unsettled, and since there is no good evidence that such treatment is ever really indicated, it seems the better part of valor to urge that this practice be universally discontinued.

Stewart and her associates[32] at Oxford reported about one year ago on the question of diagnostic and therapeutic roentgen-ray exposure in children who had recently died of acute leukemia in England, in control children of similar age and sex distribution selected at random in the general population, and in the mothers of both sets of children. The only significant difference encountered was the greater frequency of pelvimetry in the mothers of the leukemic children during the pregnancy which resulted in the leukemic child.

By coincidence, during the past two and one-half years we have also been conducting an investigation of the epidemiologic and etiologic factors underlying acute childhood leukemia, using a questionnaire and interview technique. The questions are directed at children certified to have died of acute leukemia in the State of California during the past year, their closest sibling, their most habitual playmate, and the parents of both the playmate and leukemic child. Since the Stewart report appeared, we have compiled our material and Table 1 indicates the present status of our own information on the subject. From these data,* one can draw either conclusion; namely, that abdominal roentgen-ray exposure during pregnancy is or is not significantly more frequent amongst the mothers of childhood leukemia victims, depending entirely upon which set of controls one selects for comparison. There was a difference between the pregnancies resulting in the leukemic child and the sibling, but not the leukemic child and his unrelated playmate.

The Stewart controls, it should be recalled, were selected at random from the general population. The motivation of the mothers of these controls to remember earlier roentgen-ray exposures might well be significantly less than the motivation of the mothers of the leukemic children, who would probably grasp eagerly at any possible explanation for their child's leukemia that did not involve personal guilt or neglect. For these reasons, I am forced to conclude that the evidence regarding the leukemogenic hazard of pelvimetry is still unconvincing.

Once again, however, the problem seems to be taking care of itself. I have recently discussed the question of indications for pelvimetry with Dr. Charles E. McLennan, Professor and head of the Department of Obstetrics and Gynecology at Stanford, who was himself an interested student of pelvimetry a few years ago. He pointed out quite correctly that the coming of the antibiotic era has largely eliminated the danger of infection during a trial of labor. The obstetrician today can in most doubtful cases safely permit an adequate trial of labor, secure in the knowledge that a cesarean section can still be performed without undue hazard of infection or other complications. Most instances of severe pelvic contraction are obvious on clinical

* I am indebted to my co-investigator on this project, Dr. Lincoln E. Moses, Associate Professor of Statistics, Stanford University, and to Mrs. Edythalena Tompkins for the tabulation and statistical analysis of these data. This work, which will be described more fully in a separate publication, has been supported by a grant from the National Cancer Institute, National Institutes of Health, United States Public Health Service.

TABLE I

MATERNAL ROENTGENOGRAPHIC EXAMINATIONS; ACUTE CHILDHOOD LEUKEMIA, CALIFORNIA, 1955–1956

Patient

Sibling	o	1 or 2	3+	Total
o	75	33	2	110
1 or 2	13	21	3	37
3+	—	1	2	3
Total	88	55	7	150

$\chi = 3.19$; p(.0007)

Patient

Playmate	o	1 or 2	3+	Total
o	38	32	4	74
1 or 2	31	14	2	47
3+	3	—	—	3
Total	72	46	6	124

$\chi = .35$; p(.36)

Sibling

Playmate	o	1 or 2	3+	Total
o	42	18	2	62
1 or 2	33	8	1	42
3+	2	1	—	3
Total	77	27	3	107

$\chi = 1.85$; p(.032)

MATERNAL ROENTGENOGRAPHIC EXAMINATIONS, ABDOMINAL; ACUTE CHILDHOOD LEUKEMIA, CALIFORNIA, 1955–1956

Patient

Sibling	o	1	2	3+	Total
o	101	19		3	126
1	9	11		3	23
2	—	—		1	1
3+	—	—		—	—
Total	110	30		7	150

$\chi = 2.96$; p(.0015)

Patient

Playmate	o	1	2	3+	Total
o	70	20	6	2	98
1	19	5	—	—	24
2	—	1	—	—	1
3+	2	—	—	—	2
Total	91	26	6	2	125

$\chi = .71$; p(.24)

Sibling

Playmate	o	1	2	3+	Total
o	67	12	1	—	80
1	18	5	—	—	23
2	2	—	—	—	2
3+	2	—	—	—	2
Total	89	17	1	—	107

$\chi = 1.35$; p(.089)

examination and do not require roentgenographic confirmation. There will always remain a very small residue of cases in which pelvimetry can provide necessary and useful information to the obstetrician. It may be anticipated that the indications for such limited recourse to pelvimetry will be clearly spelled out in the next few years. We have experienced a spontaneous sharp decrease in the utilization of pelvimetry by our own obstetrical staff over the past several years. Radiologists should cooperate closely with obstetricians to limit and define the indications for pelvimetry, not because any hazard has been established but merely as a matter of general policy to discourage needless or useless roentgenographic examinations.

Alarm about the hazard of radiation-induced leukemia has been revived very recently by a paper by Lewis,[20] who has reviewed all of the published data and

analyzed them from the standpoint of the geneticist looking for linearity of dose-response relationships. He satisfied himself that there was indeed a linear relationship between dose and the observed incidence of leukemia in these diverse studies. He then extrapolated the available dose-response information down to very low esposure levels, coming up with an estimated leukemia induction rate of one case per million population per roentgen per year. On this basis he estimates that ionizing radiation received from natural background sources might account for from 10 to 20 per cent of the spontaneous leukemias in this country. Since the current level of population exposure to roentgen rays during diagnostic procedures has been estimated as of roughly the same order of magnitude, a similar number of cases might be attributable to diagnostic roentgen-ray examinations, though Lewis did not explicitly make this statement. Lewis' analysis carries an important theoretic implication as well; namely, that in being linear with dose and having no threshold, the leukemogenic action of radiation resembles radiation-induced gene mutation and may thus represent an instance of malignant transformation by somatic mutation.

I am indebted to Dr. Austin Brues, head of the Biology and Medicine Division of the Argonne National Laboratory, for permitting me to refer to a critical analysis of the Lewis article which he has recently prepared for publication in a forthcoming issue of *Science*.[6] After taking a very painstaking and meticulous look at the data regarding radiation exposure in the various series analyzed by Lewis, Dr. Brues concludes that there is no good evidence for linearity in the dose-response relationships. In discussing the question of leukemia in radiologists, for example, where Lewis had uncritically adopted an "assumed average dose" in making his calculations, Brues points out: "the radiation doses incurred are not, of course, known. Speaking of an assumed average dosage is in any case unjustified, since it argues in a circle by assuming linearity of response; whereas it seems, in fact, probable that radiologists have varied widely between caution and incaution in their self-protective measures. If we are willing to accept the rather probable assumption that a substantial proportion of the radiologists received much more than the recommended dose rates, it should be clear that the obvious increase in leukemia in those physicians using radiologic techniques, while affirming the leukemogenic action of x-rays, is irrelevant to the question of whether this action is linear with dose." Dr. Brues also raises some very cogent objections to the somatic mutation hypothesis.

One other serious criticism of the Lewis paper which can properly be made is that it completely ignores the rather large body of evidence now available on the experimental induction of leukemia and lymphosarcoma in mice. Since radiation is also a very effective leukemogenic agent in the mouse, it seems only fitting to examine this evidence for its possible bearing on the human situation. Here, our own work, and that of several other investigators, immediately comes in conflict with both the somatic mutation hypothesis and the concept of a linear dose-response relationship. Although one cannot properly speak of a true threshold, there appears to be a minimal effective dose, in the vicinity of 200 r of total body exposure, below which no detectable increase in leukemia incidence has been noted. Secondly, the incidence of lymphosarcoma and lymphatic leukemia is appreciably greater when the total dose is fractionated and given in a series of treatments some three to eight days apart, rather than as a single massive dose.[14] For the purposes of the somatic mutation hypothesis, the response should be the same for a given total dose, independent of dose rate or fractionation. Moreover, the incidence of these malignant diseases may be effectively reduced, after irradiation has been completed, by alteration of the hormonal environment[15] or by the intravenous injection of compatible bone marrow cells

from another mouse.[16] Finally, it has recently beeen possible to prove that the tumors can arise in lymphoid cells from a nonirradiated animal when grafted into an irradiated host.[17] This totally indirect induction mechanism suggests that we must look for some disturbance in the internal environment of the host, rather than exclusively to a direct cellular effect of the radiation itself, as the actual and immediate cause of the neoplastic transformation.

OSTEOGENIC SARCOMA

The induction of osteogenic sarcomas by bone-seeking internal emitters like radium, plutonium, and radiostrontium in experimental animals and man is now well established. However, this is not a problem which concerns us as radiologists; it is best reserved for a discussion of the possible hazards of fall-out. Similarly, the induction of skin tumors requires relatively large or often repeated local radiation exposure and is therefore not pertinent to our main line of interest.

SHORTENING OF LIFE

Let us go on to the only remaining item of major importance among the somatic hazards; namely, the effect of radiation on longevity. There is a good deal of evidence that, after relatively *large* doses of irradiation, life span is significantly shortened in a variety of experimental animals. Blair,[4] Brues and Sacher,[7] Jones,[12] and others have attempted to construct mathematical models, utilizing some of these experimental data, which would permit an extrapolation down to very low doses, in order to arrive at an estimate of the degree of life-shortening which might be expected at occupational exposure levels. From these mathematical analyses have come the various estimates with which we are all familiar, suggesting that human life may be shortened by some days or weeks per roentgen. There may, of course, be a fundamental fallacy in such extrapolations. They are somewhat akin to the calculation that, if a 60-mile-an-hour wind will blow the roof of a house off in one minute, a 1-mile-an-hour wind will do the same thing in one hour.

Mole,[22] in a recent issue of *Nature*, has presented an admirable analysis of the experimental facts pertinent to this question. He points out that there are only eight experimental points in the entire literature pertaining to chronic exposure of rodents to weekly doses of less than 10 r or the equivalent in neutron exposure, and the duration of life actually observed was not significantly different from its control in any of these eight instances. He shows that three different curves fit the available data about equally well, and one of these, a linear fit, leads to the conclusion that there is a threshold at about 1 to 2 r per day below which no shortening of life occurs.

Shields Warren,[34] about one year ago, reported on a comparative analysis of average age at death from a variety of causes of death among radiologists and other physicians not known to have been exposed to radiation as gleaned from obituaries in the *Journal of the American Medical Association* over the twenty-five year period 1930–1954. The mean ages at death which he encountered indicated that radiologists died about five years earlier, on the average, from virtually any cause of death, as compared with physicians not generally exposed to radiation; those practicing other specialties like urology and dermatology, in which some exposure is known to occur, exhibited figures somewhere in between. Warren's article does not include information on the actual number of physicians in each category, the actual number of deaths from each cause, the age-corrected death rates in the various specialty categories, and other data necessary for a critical appraisal of his conclusions.

Lewis[20] states that Warren's data were not properly age-corrected and that the mean age of the radiologists was some six years less than that of the physicians not known to have been exposed to radiation. Applying this age correction, he finds that the radiologists' longevity is in fact slightly greater than that of physicians in general.

This is indeed reassuring and in keeping with the experimental evidence cited by Mole,[22] all of which would tend to indicate that radiologists and others occupationally exposed to radiation at or below the range of the maximal permissible dose have no need to fear a significant reduction in life span.

GENETIC HAZARDS

We come next to the genetic hazard of the medical uses of radiation. I shall not take the time here to review the fundamentals of gene mutation and of population genetics. These topics are lucidly presented in a recent review in *Science* by Glass,[10] and in the National Academy of Sciences and Medical Research Council reports.[3,11] The argument of the geneticist regarding the existence of a genetic hazard to the human population from diagnostic roentgen-ray examinations rests on the following propositions:

1. *Radiations cause gene mutations.* The classic observation of Muller on *Drosophila* has been amply confirmed by many others for a variety of plants, bacteria and other microorganisms, and more recently for mice. Although there is no direct proof that radiation is also a mutagenic agent for man, it would be foolhardy and irresponsible to brush aside as irrelevant the evidence that radiation is mutagenic in lower animals and plant forms, since it has been amply demonstrated that, with very minor variations, all living things that reproduce themselves sexually obey the same genetic laws. Moreover, the observed effects of radiation at somewhat higher dose levels on the human gonads are morphologically essentially identical with those observed in the mouse, for which an increase in mutation rates after radiation exposure has now been conclusively established. Thus I would feel that the thesis that radiations are probably mutagenic for man must be accepted by any reasonable individual.

2. *The production of mutations by radiation is linear with dose and independent of dose rate*, and is therefore not consistent with the notion of a threshold dose below which no effect will occur. Again the evidence on this point comes from the fruit fly and other lower forms. The lowest dose levels at which linearity has actually been demonstrated are in the rather substantial range of 50 r. How then is it possible for the geneticist to conclude that mutations would still occur after a dose of only 20 r, 10 r, or even less? Here again the geneticist has both reason and prudence on his side. He can properly argue that, if a threshold existed, or if there were significant recovery from the effects of very small doses, then the cumulative effect of a fractionated series of small exposures, culminating in a total dose of perhaps 100 r, should be substantially less than that of 100 r given as a single dose. The established fact that this is not so, and that mutation rates are indeed independent of dose rate and of fractionation, constitutes a powerful argument for extrapolation to very low dose levels. Secondly, even if the geneticist were to grant that we cannot be absolutely sure that this is so, he could still argue that the very fact that we are not sure should make us adopt the more careful and conservative position; namely, that there is no threshold.

3. *Most mutations are harmful.* They will tend to accumulate in the population to a level determined by natural selection and elimination of the defectives. Here again one is forced to rely on evidence drawn from lower organisms, and once again the evidence on the whole is rather convincing. This leaves open the question of how large an increase in mutation rate the population can tolerate. As deleterious mutations accumulate in a population, fertility tends to decrease and the number of defective mutations leading to early death tends to increase. Ultimately, the species would be doomed to extinction if fertility and life span dropped below critical levels.

The geneticists have no clear cut evidence on how large a perturbation in the mutation rate can be safely tolerated by man. They have chosen to take as a reasonably con-

servative estimate a doubling of the present mutation rate. This is purely arbitrary; it may be that either a much smaller or a much larger change in the human mutation rate would be the proper level to select. Since a doubling of mutation rate is generally compatible with survival of other species in which mutations can be experimentally produced, and since we have no way of establishing this point conclusively for man, it would seem that the figure chosen by the geneticists is as reasonable as any. The dose required to double the human mutation rate is of course quite unknown; the geneticists have tried to estimate it from the known doubling doses in other species. Their best estimates indicate that the human mutation rate would double after an accumulated dose, during a generation, in the range of 30 to 80 r.

4. *The dose of ionizing radiation received from natural background sources may contribute a substantial fraction of the "spontaneous" mutation rate.* If this is so, the geneticist would argue that the total gonadal exposure to diagnostic roentgen rays per generation should not be permitted to exceed the level of exposure provided by background sources. Here we are on somewhat more controversial ground. The contribution of natural background radiation to the spontaneous mutation rate in man is unknown, and may be either quite appreciable or relatively negligible. In the fruit fly it has been estimated to yield only about 1/1,000 of the spontaneous mutations. On the other hand, Russell[27] has recently found that the radiation-induced mutation rate for the mouse is some 10 to 15 times greater per roentgen than that in the fruit fly, and it is not unlikely that man resembles the mouse more than the fruit fly in this regard. Thus, the dose of background radiation received during a generation by man might well be responsible for a substantial fraction of his spontaneous mutation rate. This is the reason for the conservative position taken by the geneticists in using this figure as a basis for setting a permissible limit for diagnostic roentgen-ray exposure. Another way of looking at the question is that the dose received from background radiation may be *presumed* to be genetically safe, simply because man has successfully evolved in the environment of such exposure over so many thousands of years.

5. *What is the present level of diagnostic roentgen-ray exposure in the population?* The studies conducted by the Medical Research Council and the National Academy of Sciences clearly brought out our great ignorance on this question. In England, Osborn and Smith[25] have attempted to survey this problem, and a similar study was made in the United States by Laughlin and Pullman.[19] These authors clearly stipulate the many uncertainties involved in the estimates which they have attempted to make, and repeatedly emphasize the great need for actual dosimetric measurements under a great variety of operating conditions in hospitals, in the offices of radiologists and other physicians, and under other conditions of diagnostic exposure. Several groups are now actively at work in efforts to provide more reliable and comprehensive information on actual exposure levels, and on the extent to which they can be reduced by a variety of protective measures.[2,30,31]

DISCUSSION

Laughlin and Pullman estimate that there are a total of approximately 54 million diagnostic roentgenographic examinations per year in the United States, exclusive of the estimated 20 million mass chest survey examinations and approximately 83 million dental roentgenographic examinations. Clearly, a staggeringly large fraction of the population is receiving diagnostic roentgen-ray exposure every year. The next question then is: what level of exposure is involved, and is this significant? Laughlin and Pullman conclude that a rather low estimate of the gonadal dose received during a thirty year period by the United States population at the present time is in the vicinity of 1.5 r, and that un-

der conditions of less adequate protection the dose could be as large as 4.6 ± 3 r. The natural background radiation contributes an estimated 3 r per generation to the gonadal dose. It would thus appear that the level of genetically significant radiation currently received from diagnostic roentgen-ray examinations in the United States is of about the same order of magnitude as that from natural background radiation. Again, I see no useful purpose in disputing this estimate of the situation. Indeed, I feel that we are fortunate that the figures did not turn out to be 10 or 100 times as high.

It seems far more constructive to accept the Laughlin-Pullman figures as a working basis, for the present, and to attempt to reduce diagnostic roentgen-ray exposure to lower levels (a) by the development of new equipment which would make possible the same roentgenographic information with less exposure, (b) by more careful and rigorous use of multiple leaf collimators, filters, and gonadal shields in children and young adults, (c) by more judicious and careful weighing of the indications for diagnostic roentgen-ray examinations involving exposure of the gonadal region to the primary beam, and (d) by discouraging free recourse to fluoroscopy and roentgenography by those lacking special training in this field.

It would appear that most routine pelvimetries can and should now be eliminated. With respect to examinations of the chest, extremities, upper trunk and cranial region, proper beam collimation and positioning prevent the primary beam from covering the gonadal region, and the scattered dose is quite negligible.[34] There is thus no cause whatever for concern regarding properly conducted examinations of these regions, even in pregnant women. With respect to the indications for examination of the lumbar spine, pelvis, lower urinary or gastrointestinal tract, it is my feeling that the most effective safeguard for the patient and the public at large is the combined best judgment of the referring physician and of the radiologist.

To allow medical care to deteriorate through lack of adequate radiologic information would inflict on the public a far more severe penalty than any hypothetic benefit which avoidance of radiation exposure might confer. Physicians have an obligation to re-educate the public and to put the problem back into its proper perspective. Thus the layman must be made aware of the fact that in his daily life he accepts the far greater hazards of cigarette smoking, of driving an automobile, of living in a smog-laden atmosphere, and even of taking a bath. Most of our food contains additives and preservatives, the potential deleterious effects of which are almost entirely unknown, and which may be far more serious than those attributed to radiation.

As Brues so aptly comments: "The concept of linearly acting toxic agents has much broader implications. If it is difficult to prove or disprove it for radiations it must be all the more difficult to answer the same questions for sunlight, for man-made hydrocarbons, and for the many new drugs, insecticides and herbicides which have not undergone anything like the degree of exhaustive study that ionizing radiation has from the standpoint of minimal effects of small doses. The type of argument presented against radiation exposure would, if applied to hydrocarbons, make it very difficult to defend the use of petroleum as an energy source."

Finally, it might be pointed out that medical science has, for many years, with the full and enthusiastic approval of the population at large, been adding a burden of mutations to the germ plasm. I refer to our humanitarian efforts to prolong life, and to make possible normal marriage and reproduction, for thousands of individuals with diabetes, pernicious anemia, hemophilia, and other genetically determined maladies. All of these elements must take their proper place in any sober and realistic appraisal of this terribly complex problem.

CONCLUSIONS

This has been a lengthy and yet necessarily incomplete analysis. I would like in closing to try to reduce it to the essential

conclusions which seem to me pertinent for radiologists and for physicians in general. Radiologists are not the only group within the health professions who employ roentgen rays extensively for diagnostic purposes. Nonetheless, they have always taken the initiative in seeking to set standards for safe practices, and they should again rise to the challenge provided by these new hypothetical hazards by taking a responsible position which decries unnecessary radiation exposure.

In the field of therapeutic radiology, the newer lines of evidence add to the weight of previous opinion which would discourage the promiscuous use of roentgen rays and radium in the treatment of benign and nonneoplastic conditions, particularly in children and young adults.

In the realm of diagnostic roentgenology, I am not impressed with the evidence regarding a possible leukemia hazard but would feel that even this hypothetical hazard may be disposed of, now that the valid indications for routine pelvimetry have largely vanished. I see no good reason for concern about the effects of occupational radiation exposure at permissible dose levels, with respect to shortening of life span.

This leaves only the problem of genetic exposure. The best available estimates indicate that we are currently at about the same level as the natural background radiation level. This can undoubtedly be brought down very appreciably by the measures I have cited. I have every confidence that, by concerted effort to set a constructive and responsible example, radiologists can effectively reduce the exposure level of the population, within a very short time, to levels that will set our geneticist friends' minds at ease, without at the same time impairing the quality of diagnostic roentgenray service which now forms such an invaluable part of medical practice throughout the word.

Stanford University
School of Medicine
Clay and Webster Streets
San Francisco 15, California

REFERENCES

1. Abbatt, J. D., Farran, H. E., and Greene, R. Acute myeloid leukaemia after radioactive-iodine therapy. *Lancet*, 1956, *1*, 782–783.
2. Ardran, G. M. Dose reduction in diagnostic radiology. *Brit. J. Radiol.*, 1957, *30*, 436–438.
3. Biological Effects of Atomic Radiation; Summary Reports. National Academy of Sciences, National Research Council, Washington, D.C., 1956.
4. Blair, H. A. Formulation of injury, life span, dose relations for ionizing radiations. I. Application to mouse. UR-206, 1952.
5. Blom, P. S., Querido, A., and Leeksma, C. H. W. Acute leukaemia following x-ray and radioiodine treatment of thyroid carcinoma. *Brit. J. Radiol.*, 1955, *28*, 165–166.
6. Brues, A. M. Ionizing radiation and leukemia. *Science*. To be published.
7. Brues, A. M., and Sacher, G. A. Analysis of mammalian radiation injury and lethality. In: Symposium on Radiobiology: The Basic Aspects of Radiation Effects on Living Systems, Oberlin College, June 14–18, 1950. Nickson, J. J., Editor, John Wiley & Sons, Inc., New York, 1952.
8. Court-Brown, W. M., and Doll, R. Leukemia and aplastic anemia in patients treated with x-rays for ankylosing spondylitis. Medical Research Council, Special Report Series, H. M. Stationery Office, London, 1957.
9. Folley, J. H., Borges, W., and Yamawaki, T. Incidence of leukemia in survivors of atomic bomb in Hiroshima and Nagasaki, Japan. *Am. J. Med.*, 1952, *13*, 311–321.
10. Glass, B. Genetic hazards of nuclear radiations. *Science*, 1957, *126*, 241–246.
11. Hazards to man of nuclear and allied radiations. Medical Research Council, H. M. Stationery Office, London, 1956.
12. Jones, H. B. Special consideration of aging process, disease, and life expectancy. UCRL-3105, 1–68, 1955.
13. Kaplan, H. S. On etiology and pathogenesis of leukemias; review. *Cancer Res.*, 1954, *14*, 535–548.
14. Kaplan, H. S., and Brown, M. B. Quantitative dose-response study of lymphoid-tumor development in irradiated C57 black mice. *J. Nat. Cancer Inst.*, 1952, *13*, 185–208.
15. Kaplan, H. S., Nagareda, C. S., and Brown, M. B. Endocrine factors and radiation-induced lymphoid tumors of mice. *Recent Progress in Hormone Research*, 1954, *10*, 293–338.
16. Kaplan, H. S., Brown, M. B., and Paull, J. Influence of bone-marrow injections on involution and neoplasia of mouse thymus after systemic irradiation. *J. Nat. Cancer Inst.*, 1953, *14*, 303–316.
17. Kaplan, H. S., Hirsch, B. B., and Brown,

M. B. Indirect induction of lymphomas in irradiated mice. IV. Genetic evidence of origin of tumor cells from thymic grafts. *Cancer Res.*, 1956, *16*, 434–436.

18. LANGE, R. D., MOLONEY, W. C., and YAMAWAKI, T. Leukemia in atomic bomb survivors. I. General observations. *Blood*, 1954, *9*, 574–585.
19. LAUGHLIN, J. S., and PULLMAN, I. Gonadal dose produced by medical use of x-rays. National Academy of Sciences, National Research Council, Washington, D. C., 1957.
20. LEWIS, E. B. Leukemia and ionizing radiation. *Science*, 1957, *125*, 965–972.
21. MARCH, H. C. Leukemia in radiologists in 20 year period. *Am. J. M. Sc.*, 1950, *220*, 282–286.
22. MOLE, R. H. Shortening of life by chronic irradiation: Experimental facts. *Nature*, 1957, *180*, 456–460.
23. MOLONEY, W. C., and KASTENBAUM, M. A. Leukemogenic effects of ionizing radiation on atomic bomb survivors in Hiroshima City. *Science*, 1955, *121*, 308–309.
24. NEWELL, R. R. Radiation hazard: Its statutory control and its influence on future of human race. *Stanford Med. Bull.*, 1957, *15*, 117–122.
25. OSBORN, S. B., and SMITH, E. E. Genetically significant radiation dose from diagnostic use of x rays in England and Wales; preliminary survey. *Lancet*, 1956, *1*, 949–953.
26. POCHIN, E. E., MYANT, N. B., and CORBETT, B. D. Leukaemia following radioiodine treatment of hyperthyroidism. *Brit. J. Radiol.*, 1956, *29*, 31–35.
27. RUSSELL, W. L. X-ray induced mutations in mice. Cold Spring Harbor Symp. *Quant. Biol.*, 1951, *16*, 327–335.
28. SEIDLIN, S. M., SIEGEL, E., YALOW, A. A., and MELAMED, S. Acute myeloid leukemia following prolonged iodine-131 therapy for metastatic thyroid carcinoma. *Science*, 1956, *123*, 800–801.
29. SIMPSON, C. L., and HEMPELMANN, L. H. Association of tumors and roentgen-ray treatment of thorax in infancy. *Cancer*, 1957, *10*, 42–56.
30. STANFORD, R. W., and VANCE, J. Quantity of radiation received by reproductive organs of patients during routine diagnostic x-ray examinations. *Brit. J. Radiol.*, 1955, *28*, 266–273.
31. STANFORD, R. W. Use of cones and filters to reduce patient dosage in diagnostic radiology. *Brit. J. Radiol.*, 1957, *30*, 497–499.
32. STEWART, A., WEBB, J., GILES, D., and HEWITT, D. Malignant disease in childhood and diagnostic irradiation in utero. *Lancet*, 1956, *2*, 447.
33. ULRICH, H. Incidence of leukemia in radiologists. *New England J. Med.*, 1946, *234*, 45–46.
34. WARREN, S. Longevity and causes of death from irradiation in physicians. *J.A.M.A.*, 1956, *162*, 464–468.

Vol. 80, No. 4

THE AMERICAN JOURNAL OF ROENTGENOLOGY, RADIUM THERAPY AND NUCLEAR MEDICINE

Editor: Lawrence Reynolds, M.D.

Associate Editors: Harry Hauser, M.D., Traian Leucutia, M.D., Russell H. Morgan, M.D., Edward B. D. Neuhauser, M.D., Wendell G. Scott, M.D.

Consulting Editorial Board: See front cover.

Published by: Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Illinois.

Issued monthly. Annual subscription: United States, Mexico, Cuba, Central and South America, $15.00; Canada, $16.00; other countries, $17.00. Current single numbers, $1.50. Advertising rates submitted on application. Editorial office, 110 Professional Building, Detroit 1, Michigan. Office of publication, 301–327 East Lawrence Avenue, Springfield, Illinois. Information of interest to authors and readers will be found on page vi.

Officers and Standing Committees

AMERICAN ROENTGEN RAY SOCIETY

President: Wendell G. Scott, St. Louis, Mo.; *President-Elect:* Barton R. Young, Philadelphia, Pa.; *1st Vice-President:* John P. Medelman, St. Paul, Minn.; *2nd Vice-President:* John E. Whiteleather, Memphis, Tenn.; *Secretary:* C. Allen Good, Mayo Clinic, Rochester, Minn.; *Treasurer:* Robert K. Arbuckle, Samuel Merritt Hospital, Hawthorne and Webster Sts., Oakland 9, Calif.

Executive Council: W. G. Scott, B. R. Young, J. P. Medelman, C. A. Good, R. K. Arbuckle, Lawrence Reynolds, L. W. Paul, H. M. Stauffer, Cesare Gianturco, W. E. Chamberlain, P. C. Hodges, J. C. Cook, R. C. Pendergrass, R. M. Caulk, J. F. Holt, A. E. Childe, Wilbur Bailey, Chairman, 2009 Wilshire Blvd., Los Angeles, Calif.

Program Committee: C. A. Good, Rochester, Minn., H. M. Stauffer, Philadelphia, Pa., Lawrence Reynolds, Detroit, Mich., Cesare Gianturco, Urbana, Ill., Wilbur Bailey, Los Angeles, Calif., H. O. Peterson, St. Paul, Minn., B. R. Young, Chairman, Philadelphia, Pa.

Publication Committee: E. B. D. Neuhauser, Boston, Mass., H. G. Reineke, Cincinnati, Ohio, V. P. Collins, Houston, Texas, J. F. Roach, Albany, N. Y., H. M. Stauffer, Chairman, Philadelphia, Pa.

Finance and Budget Committee: S. W. Brown, Augusta, Ga., J. F. Holt, Ann Arbor, Mich., A. E. Childe, Winnipeg, Manitoba, Edward L. Jenkinson, Chicago, Ill., L. W. Paul, Chairman, Madison, Wis.

Committee on Scientific Exhibits: T. F. Leigh, Emory University, Ga., R. H. Marshak, New York, N. Y., Cesare Gianturco, Chairman, Urbana, Ill.

Representatives on the American Board of Radiology, H. D. Kerr, St. Michaels, Md., T. Leucutia, Detroit, Mich., C. A. Good, Rochester, Minn.

Director of Instructional Courses: H. O. Peterson, St. Paul, Minn., *Manager of Annual Meeting:* James C. Cook, 110 Professional Building, Detroit 1, Mich.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit 1, Mich.

Fifty-ninth Annual Meeting: **Shoreham Hotel, Washington, D. C., September 30–October 3, 1958.**

AMERICAN RADIUM SOCIETY

President: Milford D. Schulz, Boston, Mass.; *President-Elect:* Theodore R. Miller, New York, N. Y.; *1st Vice-President:* Theodore P. Eberhard, Ann Arbor, Mich.; *2nd Vice-President:* James F. Nolan, Los Angeles, Calif.; *Secretary:* Robert L. Brown, P. O. Box 459, Emory University, Ga.; *Treasurer:* Jesshill Love, 234 Medical Arts Bldg., 1169 Eastern Parkway, Louisville, Ky.

Executive Committee: Grant H. Beckstrand, Chairman, Long Beach, Calif.; Norman A. McCormick, Windsor, Ontario, Canada; Ralph T. Ogden, Hartford, Conn.

Program Committee: Milford D. Schulz, Chairman, Boston, Mass.; Lloyd F. Craver, New York, N. Y.; Morton M. Kligerman, New York, N. Y.; Elizabeth F. Focht, New York, N. Y.; J. Samuel Binkley, Oklahoma City, Okla.; Justin J. Stein, Los Angeles, Calif.; William S. MacComb, Houston, Texas; Theodore R. Miller (ex officio), New York, N. Y.

Publication Committee: Harry Hauser, Chairman, Cleveland, Ohio; Martin Van Herik, Rochester, Minn.; J. Robert Andrews, Bethesda, Md.

Public Relations Committee: Henri LeClaire, Chairman, Cincinnati, Ohio; John V. Blady, Philadelphia, Pa.; Harold E. Johns, Toronto, Ontario, Canada.

Janeway Lecture Committee: Gioacchino Failla, Chairman, New York, N. Y.; H. Dabney Kerr, St. Michaels, Md.; Lloyd F. Craver, New York, N. Y.

Representatives on the American Board of Radiology: Douglas Quick, New York, N. Y.; B. P. Widmann, Philadelphia, Pa.; Frederick W. O'Brien, Boston, Mass.

Representatives on the National Committee on Radiation Protection: Edith H. Quimby, New York, N. Y.; Theodore P. Eberhard, Ann Arbor, Mich.

Representative on the Board of Chancellors of the American College of Radiology: Charles L. Martin, Dallas, Texas.

Committee on Arrangements: Charles C. Stetson, Chairman, Englewood, N. J.; Henri LeClaire, Cincinnati, Ohio; Victor A. Marcial, Puerto Rico; Howard H. Ashbury, Charlottesville, Va.; Jesshill Love, Louisville, Ky.

Forty-first Annual Meeting: **The Homestead, Hot Springs, Virginia, April 6–8, 1959.**

EDITORIAL

THE INTERRELATIONSHIP OF OBSTETRIC, GYNECOLOGIC, AND UROLOGIC PROBLEMS

UROLOGY, like the specialty of radiology, is closely allied with other fields of medicine. The development of urology as a specialty is related to advancements in general surgery, internal medicine and radiology, as well as to the perfection of the cystoscope and cystoscopic technique. It is also difficult to separate the departments of urology and radiology, because of the many mutual diagnostic problems and techniques. A more intimate relationship, however, exists between urology and the specialty of obstetrics and gynecology, which leads us to integrate some of their more common problems. Historically, the two specialties have been closely related. In some institutions, urology in the female developed as a part of the gynecologic service. Thus, gynecology has contributed considerably to the growth of urology as a specialty. Embryologically, anatomically, physiologically and pathologically, the urinary tract and the female pelvic organs are closely associated. Responses to hormonal secretions and problems of infection are similar. It is this interrelationship which leads to confusion when evaluating symptoms and physical findings.

Since the urinary and reproductive organs evolve from the same embryonic tissue, developmental abnormalities of the uterus and adnexae may be associated with anomalies of the urinary tract. In the presence of a bicornate uterus, the obstetrician should look for a double ureter or a duplex kidney pelvis. Reduplication of the ureter is a common urologic anomaly, and the practice of inserting catheters into the ureters prior to extensive pelvic surgery is no guarantee against a possible section of an anomalous ureter. For this reason, excretory urography or a careful retrograde study is advisable in preparation for such surgery. Solitary ectopic kidneys are rare, but they do occur, and this must be remembered when dealing with obscure pelvic tumors. The removal of an ectopic kidney, even in the presence of a second kidney, should only be done after careful consideration.

In the study of incontinence, it is well to remember that an extravesical ureteral opening in the urethra or vagina may be a source of drainage and the discharge from the urethral diverticulum may be mistaken for incontinence. Stress incontinence is principally a gynecologic problem and is corrected by gynecologic surgery. The use of the metal bead chain as recommended by Hodgkinson and Kelly[1] in the study of the urethral vesical pubic relationship as well as the posterior urethral angle may require roentgenologic assistance. In evaluating the results of surgical procedures devised to elevate the urethra or produce posterior rotation of the bladder, it is desirable to have preoperative roentgenograms for comparison. The lymphatics and the vascular supply are similarly related. This intimate relationship of the lymph channels and the drainage from the uterine cervix over the vesical neck may account for urgency, frequency and dysuria arising from cervical infection; similarly cervical carcinoma may spread to involve the bladder, ureters and urethra and may result in vesicovaginal fistula and ureteral stenosis. The constitutional symptoms associated with appendicitis and salpingitis, such as pelvic pain and dyspareunia, may be of ureteral origin, as

[1] Hodgkinson, C. P., and Kelly, W. T. Urinary stress incontinence in the female. *Obst. & Gynec.*, 1957, *10*, 493–499.

demonstrated by stricture, calculus, pyelitis and hydronephrosis.

By comparing clinical data obtained from our contacts with various specialists, we may correlate different viewpoints and aid greatly in the diagnosis, often without additional roentgen study. The radiologist may be the first to suspect hydronephrosis as the result of a pelvic mass or to recognize an obstructed ureter after pelvic surgery. He may differentiate a distended bladder from an ovarian cyst. In this way he bridges the gap between the urologist, obstetrician and gynecologist, and points the way to urologic consultation. Conversely, a deviated right ureter may lead to a diagnosis of appendiceal abscess, and an obstructed ureter to a distant primary malignancy.

By his personal supervision and the use of a flexible examination rather than the reliance upon the routine technique or judgment of the technician, the radiologist may be able to curtail the investigation in the event of an unrecognized pregnancy or expand it when the diagnosis is obscure.

During pregnancy, diseases of the urinary tract often cause greater residual damage than if the patient were not pregnant. Pregnancy complicates urinary tract disease primarily as the result of impaired urinary drainage. Physiologic dilatation attributed to progesterone and pressure of the enlarging uterus on the ureters make the urinary tract more susceptible to infection and stone formation. The bladder capacity increases as the muscle tone or peristaltic activity of the ureters decreases. Studies have shown that the pressure phenomena of a gravid uterus differ considerably from those of a pelvic tumor where there is no hormonal influence. Renal calculi are more prevalent in pregnant women but are usually well tolerated when infection is controlled. Passing ureteral catheters aids in drainage and may be adequate treatment. Rarely is removal of a stone necessary. Most congenital urinary tract lesions are well tolerated in the absence of infection or hypertension, but renal ectopia, especially a pelvic kidney, may be a source of dystocia. Women with one kidney can usually tolerate pregnancy satisfactorily when good compensatory function is demonstrated in that kidney.[2] More and more in the field of obstetrics, women are presenting themselves for examination before attempting pregnancy. This makes it possible to subject patients with hypertension, a history of renal disease or previous renal surgery to a complete urologic examination before pregnancy occurs.

Grave concern is frequently shown regarding the use of roentgen pelvimetry, but less noticeable is the cry against other roentgenographic examinations during pregnancy. Very little is said against the use of retrograde or excretory pyelography during pregnancy. Perhaps this is because the indication seems more specific or because the danger to the pregnant mother seems more grave and therefore the advantages outweigh the possibility of genetic harm. The fact remains that it is difficult to recognize or evaluate acute or pre-existing renal disease when roentgen studies are made during pregnancy. The distortion of the urinary tract obscures many common diagnostic points of urinary infection. A survey of the urinary tract before pregnancy occurs or deferment until after delivery, whenever possible, is preferable. However, when indicated, proper roentgen studies should not be discouraged. All procedures in medicine and surgery entail certain calculated risks; there should be no hesitancy in utilizing roentgenography as a diagnostic procedure, if the technique is properly carried out. This implies knowledge and utilization of every known protective device. However, granting the potential increase in genetic mutation as a side effect of medical roentgenography, its importance is secondary to that of the welfare of the individual. Natural selection and survival of the fittest has not yet governed medical treatment.

When contemplating new diagnostic procedures, one must remember that the ob-

[2] Kittredge, W. E., and Crawley, J. R. Surgical renal lesions associated with pregnancy. *J.A.M.A.*, 1956, *162*, 1353–1356.

stetrician lives by the maternal and fetal mortality statistics and any diagnostic procedure which might affect these must be weighed with great care. Recently, angiography has been suggested as a means of differentiating early intrauterine pregnancy from tubal pregnancy, but posterior colpotomy is less hazardous. Also, in the search for placenta previa and other abnormal placental implants, angiography and injection of opaque media into the amniotic sac have been reported as safe procedures. These procedures must, however, be approached with caution. Despite the foregoing, the diagnosis of unruptured extrauterine pregnancy is still very difficult and may be aided by angiography in select cases.

Modern obstetrics has not, as yet, found a method by which injury to the bladder supports can be entirely prevented and labor is still often the cause of cystocele, rectocele and incontinence. A discussion of eclampsia and lower nephron nephrosis, because they are better classified in the field of internal medicine, and many neoplastic lesions involving the genital and urinary tracts, because they are a more appropriate subject matter for general surgery, has purposely been omitted.

The division of medical practice into specialties is like dividing the waters of the world into the seven seas—it is impossible to see where one begins and the other ends. The interrelationship of certain problems, therefore, cannot be avoided. In the fields of obstetrics, gynecology and urology, the role of co-ordination of most of these problems transgresses into the specialty of radiology.

K. K. Latteier, M.D.

NATIONAL COMMITTEE ON RADIATION PROTECTION AND MEASUREMENTS (NCRP)

SUPPLEMENT TO RADIATION HANDBOOKS SUMMARIZES NEW RECOMMENDATIONS ON MAXIMUM PERMISSIBLE DOSE

AN 8-page supplement to the National Bureau of Standards Handbooks[1] dealing with radiation protection and related matters has been prepared by the National Committee on Radiation Protection and measurements (NCRP). Entitled *Maximum Permissible Radiation Exposures for Man*, the supplement summarizes the new recommendations of the NCRP on safe limits of radiation exposure; it extends and clarifies the Preliminary Statement issued by the Committee in January 1957.[2] The new publication introduces only minor changes and is intended to be in general conformity with the philosophy expressed in the April 1956 statements of the International Commission on Radiological Protection (ICRP).[3]

The recommendations of the NCRP, an advisory group of experts in various phases of the radiation field, are regularly published in the NBS Handbook series. Several of these Handbooks are now being revised to bring them into conformity with the new recommendations. Pending the availability of the revised Handbooks, the present supplement provides a simplified statement of the changes needed to comply with the new recommendations.

Further details on the new supplement are given in the following excerpts from its introduction.

EXCERPTS FROM NCRP STATEMENT

On January 8, 1957 the National Committee on Radiation Protection and Measurements issued a Preliminary Statement setting forth its revised philosophy on Maximum Permissible Radiation Exposures to Man.[2] Since that time several of the NCRP sub-committees have been actively studying the necessary revisions of their respective Handbooks. These studies have shown the need for (1) clarification of the earlier statement and (2) modification or extension of some of the concepts in that statement. Furthermore, the ICRP has made minor changes in their recommendations. Accordingly the NCRP has prepared a set of guides, given below, that will assure uniformity in the basic philosophy to be embodied in the several Handbooks. Since many of the Handbooks are followed closely in planning radiation operations in the U. S., and since the modification of a Handbook may require many months of effort, it seems wise to make the overall guiding principles available in advance of the reissuance of the revised Handbooks. These guides are not designed to take the place of any of the Handbooks; the principles given below will be extensively treated later in appropriate places. In the meantime Handbook revisions or supplementary statements will be issued as rapidly as possible. . . .

The changes in the accumulated MPD (Maximum Permissible Dose) are not the result of positive evidence of damage due to use of the earlier permissible dose levels, but rather are based on the desire to bring the MPD into accord with the trends of scientific opinion; it is recognized that there are still many uncertainties in the available data and information. Consideration has also been given to the probability of a large future increase in radiation uses. In spite of the trends, it is believed that the risk involved in delaying the activation of these recommendations is very small if not negligible. Conditions in existing installations should be modified to meet the new recommendations as soon as practicable, and the new MPD limits should be used in the design and planning of future apparatus and installations. Because of the impact of these changes and the time required to modify existing equipment and installa-

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

Principles of Urology; An Introductory Textbook to the Diseases of the Urogenital Tract. By Meredith F. Campbell, M.S., M.D., F.A.C.S., Emeritus Professor of Urology, New York University. Cloth. Price, $9.50. Pp. 622, with 319 illustrations. W. B. Saunders Company, 218 West Washington Square, Philadelphia 5, Pennsylvania, 1957.

This latest book by Dr. Campbell might be said to be a condensation of his three-volume Urology (1954), and his Clinical Pediatric Urology (1955). As Dr. Campbell states in his preface, this book was written primarily for "instruction of the student in the broad fundamentals of Urology and to serve as a practical guide for the physician who is not a urologic specialist."

The book is excellent in organization, well written, as only Dr. Campbell can write, and includes clear concise illustrations and roentgenographic reproductions pertinent to the subject and disease.

Dr. Campbell's interest in pediatric urology has shown its effect in this book by his reference to problems pertaining to and encountered in the young individual. This field in most earlier books of this kind has been deficient.

Aside from the usual chapter headings of a urologic book, attention is drawn to these subjects which are of increasing interest today: *Neuromuscular Uropathy*, *The Adrenals*, *Urology in the Female*. For the instructor in urology and the beginning student in urology, there is a section at the end of the book which lists questions applied to each chapter. The answers are to be found in the text denoted by page number.

This is a splendid book for its purpose, made possible by Dr. Campbell's ability to condense information from his two more extensive books mentioned in the first paragraph. It is recommended to the beginning student, the instructor of urology, and the physician other than the urologic specialist.

Robert C. Thumann, M.D.

Aortography; Its Application in Urological and Some Other Conditions. By W. Barr Stirling, Ch.M., F.R.C.S. (Ed.), F.R.F.P.S.G., Senior Assistant, Urological Department, Glasgow Royal Infirmary; Consultant Urologist, Ministry of Pensions. Cloth. Price, $10.00. Pp. 292, with 155 illustrations. The Williams & Wilkins Company, Mount Royal and Guilford Avenues, Baltimore 2, Maryland, exclusive U. S. agents, 1957.

This monograph reflects the personal experience of the author with some 500 aortographies performed for the diagnosis and management of various renal conditions. It is written primarily from the urologic standpoint with only thirty pages devoted to intrinsic vascular disease. For this reason its value to the vascular surgeon and the radiologist is somewhat decreased.

A very excellent historical résumé of apparatus, procedure, and development of contrast media is presented and followed by minutely detailed chapters on surgical anatomic considerations, equipment used, anesthesia, procedural difficulties, hazards and complications. The bulk of the text concerns individual renal abnormalities which are exquisitely illustrated by full page roentgenographic reproductions. The aortograms shown are among the finest we have ever seen, and this is by far the outstanding feature of the book.

It would seem that the author's primary aim was to dispell the reluctance on the part of many urologists and surgeons to make use of this valuable diagnostic adjunct. If this text were on the bookshelf of every hospital urologic department, this aim would most certainly be accomplished.

Arch H. Hall, M.D.

The Lower Urinary Tract in Childhood; Some Correlated Clinical and Roentgenologic Observations. By Sven Roland Kjellberg, Nils Olof Ericsson, and Ulf Rudhe. Cloth. Price, $18.00. Pp. 298, with 265 illustrations. The Year Book Publishers, Inc., 200 East Illinois Street, Chicago 11, Illinois, 1957.

This book is principally a roentgenologic atlas of cystourethrograms of pathologic states

of children. It was compiled from 1,155 cases by a team of one urologist and two roentgenologists at the Pediatric Clinic of Karolinska Sjukhuset, Stockholm, Sweden. Whereas treatment forms part of the discourse, diagnosis of the cystourethrographic findings constitutes the basic subject of the book.

The first five chapters are "groundwork chapters" which lay the foundation for the subsequent chronologic disease presentations. The first two chapters deal with embryology and anatomy and contain excellent illustrations from a variety of other books plus clear cystourethrographic illustrations by the authors. The following three chapters give the technique, complications of cystourethrography, and method of obtaining the material embodied in the subsequent chapters.

Headings of the topics discussed and illustrated by cystourethrography are as follows: Ectopic Ureter and Ureterocele, The Neurogenic Bladder, Bladder Neck Obstruction, Selected Aspects of Urinary Tract Infection, Urethral Valves, Stricture of the Urethra, Urethral Polyp, Congenital Hypertrophy of the Verumontanum, Intersexuality, Diverticula of the Urethra and Enuresis.

The technique of obtaining the cystourethrograms is that of the voiding method as opposed to the retrograde instillation of radiopaque material. The authors also present a special sling posture procedure to better obtain the voiding film.

The illustrations are as fine as anyone can wish, and the subject at hand is well covered. The book makes a most desirable addition to the library of the urologist, the pediatric urologist in particular, and to the library of the roentgenologist.

Robert C. Thumann, M.D.

Television in Science and Industry. By V. K. Zworykin, E.E., Ph.D., D.Sc.(hon.), Honorary Vice-President and Technical Consultant, Radio Corporation of America; E. G. Ramberg, Ph.D., Research Physicist, RCA Laboratories, Princeton, N. J.; and L. E. Flory, B.S. (E.E.), Research Engineer, RCA Laboratories, Princeton, N. J. Cloth. Price, $10.00. Pp. 300, with numerous illustrations. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, New York, 1958.

The senior author of this book, Dr. Zworykin, is one of the foremost pioneers in the field of television, since his most notable invention was the iconoscope or television's first electronic "eye." The book is divided into five chapters which deal with television and its various fields of application.

Of particular interest to physicians is the section dealing with medicine and biology and the field of education. We have all seen closed Television Clinics which have been put on by various sponsors at national and local meetings in which widely scattered audiences may view the details of various technical procedures. A section describing a television microscope representing a combination of a television chain and a conventional microscope is fascinating to contemplate. This has the important advantage of greatly reducing viewing fatigue as one can observe a large bright image compared with looking into a microscope directly through an eye piece. Viewing of x-ray transparencies can also be greatly improved by making possible variations in contrast through electronic enhancement to bring out obscure details not clearly perceptible on conventional observations.

A most interesting application of electronic selection in counting circuits can be used for counts of such particles as blood cells or cell nuclei. Such techniques can be made fully automatic and will assume increasing importance because of the necessity of routine blood counts in the study of radiation exposure and for abnormal cell counts as an aid in early cancer diagnosis.

The field of consultation in medicine is greatly widened through the possibility of using color or conventional television by consultants who can be in the same or different rooms of a building or even in different cities providing there has been a link established between the sites of transmission and reception. In such manner a skilled consultant can greatly multiply his efficacy and utilization of time as well as extend the geographic area to be served.

For radiologists the most important application of television is in fluoroscopy where, by use of such a system as devised by Drs. Russell Morgan and R. E. Sturm at Johns Hopkins University, it is possible to pick up and amplify the fluoroscopic image and transmit it to a distant screen for viewing. This finds its greatest usefulness, of course, in teaching a large number of students simultaneously in different teletheaters.

Many other fascinating applications of television in various fields are described in detail

such as in dentistry where the patient or others may watch intra-oral procedures on a monitor in the same or in different rooms. Other uses are described in commerce where a central monitor can be on the lookout for suspicious actions on the part of customers and remote shipping and loading docks can be observed.

This is a thrilling book to read, opening up a field stunning even to the imagination.

Lewis E. Etter, M.D.

The Year Book of Radiology (1957–1958 Series). Radiologic Diagnosis edited by John Floyd Holt, M.D., Professor, Department of Radiology, University of Michigan; and Fred Jenner Hodges, M.D., Professor and Chairman, Department of Radiology, University of Michigan; Radiation Therapy edited by Harold W. Jacox, M.D., Professor of Radiology, College of Physicians and Surgeons, Columbia University; Chief, Radiation Therapy Division, Radiologic Service, Presbyterian Hospital, New York City; and Morton M. Kligerman, M.D., Associate Professor of Radiology, College of Physicians and Surgeons, Columbia University; Associate Attending Radiologist, Presbyterian Hospital, New York City. Cloth. Price, $10.00. Pp. 445, with 335 illustrations. The Year Book Publishers, Inc., 200 East Illinois Street, Chicago, Illinois, 1957.

The usual excellence of this valued yearly addition to the radiologist's bookshelf has been maintained in the 1957–1958 Series. The most important articles relating to radiology in world medical literature from June, 1956 through June, 1957 have been condensed for easy and rapid review.

In keeping with the suddenly popular and controversial issues concerning the relationship of radiation to longevity and genetic effects in man, the authors have based their introductory remarks on the biologic hazards of diagnostic and therapeutic radiology. Representative articles dealing with these problems are included. Appropriate editorial comment and explanation has been added throughout the text. Most of the articles are more than mere abstracts. They are condensations retaining pertinent factual data, graphs, tables, photographs, and roentgenographic reproductions. Many excellent articles from foreign journals and smaller American journals are included which would not ordinarily be available to the average radiologist.

One cannot expound on the individual articles but the authors have given most thoughtful consideration to their selection. Some subjects such as the series on platybasia are chosen as a general review of a complicated and controversial phase of roentgen diagnosis. Others are chosen because they expand or describe a new principle in radiation therapy. Radiobiology, physics, dosimetry, techniques and radiation injuries are again included in the well organized text.

Older radiologists are undoubtedly familiar with The Year Book of Radiology. It is therefore to the younger men in the profession that this book is most highly recommended.

Arch H. Hall, M.D.

BOOKS RECEIVED

Twenty-fourth Semiannual Report of the Atomic Energy Commission. By United States Atomic Energy Commission. Paper. Pp. 410, with illustrations and tables. United States Government Printing Office, Washington, D. C., 1958.

Le Médiastin et sa pathologie. By Maurice Bariety, Professeur de Clinique médicale à l'Hôtel-Dieu, Membre de l'Académie de Médecine; and Charles Coury, Médecin des Hôpitaux de Paris. Cloth. Price, 11,000 fr. Pp. 854, with 312 illustrations. Masson et Cie, Éditeurs, 120 boulevard Saint-Germain, Paris 6e, France, 1958.

The Practice of Nuclear Medicine. By William H. Blahd, M.D., Chief, Radioisotope Service, Veterans Administration Center, Los Angeles, California; Assistant Clinical Professor of Medicine, School of Medicine and Medical Physics Physician, Radiological Safety Division, University of California at Los Angeles; Franz K. Bauer, M.D., Chief, Outpatient Services, Los Angeles County Hospital; Associate Clinical Professor of Medicine and Coordinator of Radioisotope Research, University of Southern California School of Medicine; Associate Clinical Professor of Medicine, College of Medical Evangelists School of Medicine; Attending Specialist—Radioisotope Service, Veterans Administration Center, Los Angeles, California; and Benedict Cassen, Ph.D., Chief, Medical Physics Section, Atomic Energy Project and Clinical Professor of Biophysics, University of California at Los Angeles School of Medicine; Consultant in Radioisotopes—Radioisotope Service, Veterans Administration Center, Los Angeles, California. Cloth. Price, $12.50. Pp. 407, with 112 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1958.

Radiation Protection. By Carl B. Braestrup, Director, Physics Laboratory, Francis Delafield Hospital; Associate, Department of Radiology,

Columbia University, New York, New York; and Member, Executive Committee, National Committee on Radiation Protection and Measurements; and Harold O. Wyckoff, Chief, Radiation Physics Laboratory, National Bureau of Standards, Washington, D. C.; and Secretary, International Commission on Radiological Units and Measurements. Cloth. Price, $10.50. Pp. 361, with figures and tables. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1958.

The Year Book of Cancer, 1957–1958. Compiled and edited by Randolph Lee Clark, Jr., B.S., M.D., M.Sc. (Surgery), D.Sc. (Hon.), Houston, Texas, Director and Surgeon-in-Chief, The University of Texas M. D. Anderson Hospital and Tumor Institute; Professor of Surgery, The University of Texas Postgraduate School of Medicine; Clinical Professor of Surgery, Baylor University College of Medicine; and Russell W. Cumley, B.A., M.A., Ph.D., Houston, Texas, Director of Publications, The University of Texas M. D. Anderson Hospital and Tumor Institute; Professor of Medical Journalism, The University of Texas Postgraduate School of Medicine. Cloth. Price, $8.00. Pp. 523, with 191 illustrations. Year Book Publishers, Inc., 200 E. Illinois Street, Chicago 11, Illinois, 1958.

Klinisch-röntgenologische Differentialdiagnostik der Lungenkrankheiten. By Dr. Lasar Dünner, Chefarzt der Industrial Chest Diseases Clinic in Hull (England), früher ärztl. Direktor des Hospitals Buch-West in Berlin, dirig. Arzt der Abt. für Lungenkrankheiten im Jüdischen Krankenhause in Berlin. Cloth. Price, DM 69.—. Pp. 362, with numerous illustrations. Ferdinand Enke Verlag, Hasenbergsteine 3, Stuttgart-W, Germany, 1958.

Principles of Radiographic Exposure and Processing. By Arthur W. Fuchs, Rochester, New York. Cloth. Price, $10.50. P. 284, with 159 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1958.

Dermatologie und Venerologie. Volume II, Part I. Physikalische Behandlung—Dermatologische Kosmetic—Krankheiten noch unbekannter Herkunft nach Ihrer Morphologie. By Prof. Dr. Dr. h. c. H. A. Gottron, Tübingen; and Prof. Dr. Dr. h. Schönfeld, Heidelberg. Cloth. Price, DM 173.—. Pp. 757, with 388 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1958.

Handbuch der Tuberkulose. Volume I. Allgemeine Grundlagen. Edited by Prof. Dr. J. Hein, Tönsheide; Prof. Dr. Dr. h. c. H. Kleinschmidt, Hoffen; and Prof. Dr. E. Uehlinger, Zürich. Cloth. Price, DM 178.—. Pp. 832, with 244 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1958.

Hemophilic Arthropathies. By Henry H. Jordan, M.D., Orthopaedic Surgeon and Chief of Hemophilia Clinic, Lenox Hill Hospital; and Consulting Orthopaedic Surgeon, Manhattan State Hospital, New York City. Cloth. Price, $8.50. Pp. 255, with 64 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1958.

Annual Report on the Results of Treatment in Carcinoma of the Uterus. Eleventh Volume. Statements of Results Obtained in 1951 and Previous Years (collated in 1957). Editorial Committee: Dr. H.-L. Kottmeier (Editor), Stockholm; Dr. J. B. Blaikley, London; Dr. H. Martius, Göttingen; Dr. Joe V. Meigs, Boston; and Phil. Dr. C.-O. Segerdahl, Stockholm. Paper. Pp. 266, with numerous tables and illustrations. Editorial Office of Annual Report, Radiumhemmet, Stockholm 60, Sweden, 1958.

Industrial Nuclear Development; A Challenge to the States; Proceedings of a Conference sponsored by the Nuclear Energy and Employee Health and Benefits Committees of the National Association of Manufacturers and by the National Industrial Council, May 21–22, 1958, New York. Paper. Price, $2.00. Pp. 64, National Association of Manufacturers, 2 East 48th Street, New York 17, New York, 1958.

Selected Papers from the Institute of Cancer Research: Royal Cancer Hospital and from the Royal Marsden Hospital 1956. Published by order of the Committee of Management of the Institute and the Board of Governors of the Royal Marsden Hospital, London. Volume 11. Cloth. Pp. 928, with numerous illustrations. The Chester Beatty Research Institute, Fulham Road, London S.W. 3, England, 1958.

Roentgen-Diagnostics. Progress Volume I. By H. R. Schinz, R. Glauner, and E. Uehlinger. Translated from the German by James T. Case, M.D., D.M.R.E. (Cambridge). Cloth. Price, $35.00. Pp. 623, with 545 figures. Grune & Stratton, Inc., 381 Fourth Avenue, New York 16, New York, 1958.

Roentgen Manifestations of Adult Rheumatoid Arthritis; with Special Regard to the Early Changes. Acta Rheumatologica Scandinavica, Supplementum 1, 1958. By Pekka Soila. Pp. 144, with 63 illustrations. Acta Rheumatologica Scandinavica, Stockholm, Sweden, 1958.

ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M.D., Harper Hospital, Detroit 1, Michigan

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Head

Goettsch, H. B.: Radiology of the craniocervical region 719

Tristan, T. A., and Hodes, P. J.: Meningiomas of the posterior cranial fossa 720

Schnitker, M. T., and Ulrich, R. P.: Observations on the twenty-four hour pneumoencephalogram with special reference to the diagnosis of cortical atrophy 720

Etter, L. E., and Youngue, E. L.: Small pneumoencephalograms as a screening procedure in the study of convulsive disorders ... 720

Lodwick, G. S.: Cystic degeneration in glioblastoma multiforme: Trapped-air sign 721

Gloning, K., and Klausberger, E. M.: Investigations of the cerebral vascular function on the movie film 721

Lagarde, C., Vigouroux, R., and Perrouty, P.: Agenesis of the terminal end of the internal carotid, aneurysm of the anterior communicating artery; radiologic documents .. 722

Paillas, J.-E., Bonnal, J., Berard-Badier, M., and Serratrice, G.: The arteriovenous angiomas of the brain in childhood 722

Neck and Chest

Dybicki, J., Bochinski, K., and Dworak, W.: Case of accessory tracheal bronchus 722

Scheff, S., Kaufman, S. A., and Levene, G.: The laminagraphic appearance of ectopic right upper lobe bronchi 722

Barthel, H.: Diagnostic errors of surgical diseases of the lungs 723

LaVielle, C. J., and Campbell, D. A.: Neurofibromatosis and intrathoracic meningocele .. 723

Barcia, A., Oliveira Ilha, D., Fiandra, O., and Cortés, R. New acquisitions in the roentgenologic diagnosis of cardiopathies ... 723

Stevens, G. M.: Buckling of the aortic arch (pseudocoarctation, kinking): a roentgenographic entity 723

Genitourinary System

Taylor, J. N., and Genters, K.: Renal angiomyolipoma and tuberous sclerosis 724

Auvert, J.: Reflux from the kidney pelvis, studied by urinary manometry. Pathogenesis of ascending interstitial nephritis 724

Hanafee, W., Ottoman, R. E. and Wilk, S. P.: Roentgen diagnosis of urinary complications following radical hysterectomy and pelvic lymph node dissection 725

Guze, L. B., and O'Shea, W.: Experimental hydronephrosis produced by beta irradiation of the ureter 725

Fisher, M. S., Torre, A. V., and Wohl, G. T.: Fatal uremia due to uric acid crystals in a case of lymphosarcoma 726

Kincaid, O. W.: Translumbar aortography ... 726

Van Velzer, D. A., and Lanier, R. R.: A simplified technic for nephrotomography ... 726

Skeletal System

Hinkel, C. L.: Fractures of the distal radius and ulna and dislocation of the proximal carpals 727

Brown, W. H., Dennis, J. M., Davidson, C. N., Rubin, P. S., and Fulton, H.: Posterior dislocation of the shoulder 727

Nagle, D. B.: Whiplash injuries of the cervical spine 727

Bavendam, F. A.: Fractures of the carpal bones 728

Piatt, A. D.: Some significant aspects of fractures of the calcaneus 728

Jones, P. A.: The immediate prognosis of intracapsular fractures of the neck of the femur. 728

ROENTGEN DIAGNOSIS

Head

Goettsch, H. B. Radiology of the cranio-cervical region. *J. belge de radiol.*, No. 6, 1957, *40*, 739–762. (From: The Department of Radiology of the St. Elisabeth Hospital at Tilburg, Tilburg, Netherlands.)

The author discusses various bony anomalies of the cranio-cervical region which may produce disturbances of the nervous system. Symptoms may be produced by soft tissue deformities and small bone anomalies may not be visualized on the roentgenograms occasionally. Careful clinical examination of the patient is extremely important.

Embryologically, the occipital bone arises from three occipital vertebrae which fuse almost completely. The corpus of the third occipital vertebra, the pro atlas, forms the tip of the dens. Ossification appears during the second year and in the twelfth year of age it fuses with the dens. The greatest portion of the dens is formed by the body of the atlas which fuses with the epistropheus in the sixth, or seventh year of age. In many cases of anomalies occurring in this region, neurologic symptoms may not be present because of complete compensation. When this compensation disappears because of trauma, sudden symptoms may appear.

The author suggests roentgenograms of the skull made in the posteroanterior, lateral, basal, Towne and Schüller positions. These may be supplemented by laminagraphy in the sagittal and frontal planes, exposures in flexion and extension, stereoscopy and enlargement techniques.

The following lines and angles have proved of value:

(*A*) In the lateral view of the skull: (a) Bogaard's angle is formed by a line from the dorsum sellae to the basion and a line from the basion to the most dorsal situated point of the foramen magnum (average 127 ± 10 degrees); (b) Welcker's angle is formed by a line from the nasion to the tuberculum sellae and from there to the basion (average 135 ± 10 degrees); (c) Bull's angle is formed by the intersection of the plane of the hard palate and the plane of the atlas; (d) Chamberlain's line extends from the most dorsal point of the hard palate to the posterior margin of the foramen magnum; and (e) McGregor's line extends from the most dorsal point of the hard palate to the lower border of the squama occipitalis. Chamberlain's and McGregor's lines are of value in locating the upper margin of the dens, which should not extend more than 5 mm. above the line of Chamberlain.

(*B*) On the posteroanterior laminagram: Fischgold lines which consist of: (a) bimastoid line, drawn from the lower margin of one mastoid process to the other; and (b) a biventer line, drawn from the bigastric sulcus from one side to the other. The distance between these lines should be about 10 mm. The bimastoid line cuts the upper margin of the dens and intersects the atlanto-occipital joints.

The congenital malformations of importance, which alone or in combination can produce symptoms, are as follows:

(1) *Basilar Impression:* The borders of the foramen magnum are introverted and a plane through this foramen lies in the interior of the skull. This may be congenital or acquired in diseases associated with decalcification of the skull. Basilar impression is best visualized in the lateral and Towne's views, especially on laminagrams.

(2) *Platybasia:* This is a form of partial basilar impression resulting in an elevated dens and a flat clivus. There is an increase in the angles of Welcker and Bull. When present, symptoms are accentuated by maximal flexion of the head.

(3) *Hypoplasia of the Clivus:* This is due to a disturbance in the development of the corpora of the first and second occipital vertebrae. The foramen magnum is enlarged and the upper margin of the dens lies in or above the plane of the foramen. The clivus may be shortened or assume a more horizontal position. The acquired form is caused by tumors, of which the chordoma is the most frequent.

(4) *Deformations of the Foramen Magnum:* This is noted in the first three conditions mentioned above. Except in the case of hypoplasia of the clivus there nearly always is a constriction of the foramen magnum. The lumen of the dural canal may be constricted by dural bands. Schüller's projection and laminagraphy are necessary for detailed study.

(5) *Manifestations of an Occipital Vertebra:* While there are many variations, the most simple form is the persisting ossiculum terminale. In most cases the foramen magnum is deformed by the position of the occipital condyles causing congenital torticollis.

(6) *Assimilation of the Atlas:* If the posterior arch of the atlas only is assimilated, a large empty space between the occipital bone and the spinous process of C-2 will be noted in the lateral view. The assimilation of the atlas and the fusion of the second and third cervical vertebrae occur frequently in combination. The anterior portion of the atlas arch may exist as an independent ossiculum in front of the dens.

(7) *Congenital Malformations of the Nonassimilated Atlas:* Since the atlas originated from several centers of ossification, hypoplasia or aplasia of one or more of these nuclei may result in abnormal fissures or defects. The most frequent deformity is the spina bifida posterior.

(8) *Block-formation of the Upper Cervical Vertebrae:* Congenital fusion between any two of the cervical vertebrae may occur. There is a gradual transition of isolated fusions to the more complete fusions as seen in the syndrome of Klippel-Feil.

(9) *Os Odontoideum:* Normally, the bony center of the dens fuses with the second cervical vertebra about the sixth year of life. When this fusion does not occur

the dens remains a separate ossicle, kept in place by its fibrous connection. This must be differentiated from fracture of the dens. If the ligamentous fixation becomes loosened, instability will result.

(10) *Hypoplasia and Aplasia of the Dens:* The dens may be partially or completely absent, producing instability of this segment.

(11) *Disturbances in the Stability of the Craniocervical Region*: This can be demonstrated on roentgenograms made during maximal flexion and extension of the skull by noting the relation of the dens to the foramen magnum. The width of the atlanto-axial joint is significant. The normal values are 5 mm. in children and 2 mm. in adults.

The author reports six cases in detail, demonstrating various combinations of abnormalities of the cranio-cervical region.—*J. N. Ané, M.D.*

Tristan, Theodore A., and Hodes, Philip J. Meningiomas of the posterior cranial fossa. *Radiology*, Jan., 1958, *70*, 1–14. (Address: T. A. Tristan, Strong Memorial Hospital, 260 Crittenden Blvd., Rochester 20, N. Y.)

The major clinical characteristics of meningiomas arising from the dura in the region of the posterior cranial fossa are reviewed. Findings observed in patients at the Graduate Hospital and the Hospital of the University of Pennsylvania from the year 1918 through 1955 are presented. The study is based on the records of 59 patients.

The posterior fossa meningiomas arise in the following sites: Class I, cerebellar convexity; Class II, tentorium cerebelli; Class III, posterior surface of the petrous portion of the temporal bone (meningiomas of the cerebellopontine angle); Class IV, clivus; Class V, foramen magnum. Fourteen of the 59 cases in this series were in Class I, and 28 were in Class III. In some patients, it was impossible to tell from which portion of the dura the meningioma arose.

Few intracranial tumors offer as much difficulty in diagnosis as posterior fossa meningiomas. The clinical picture varies remarkably, depending on the location and size of the tumor. Headache is an early and common complaint. Sometimes there is radiation of pain to the neck and shoulder girdle. Hemiplegia, triplegia, and even tetraplegia may ensue. If the cranial nerves are involved, localization of the tumor is simplified. Posteriorly placed tumors may cause difficulty in speaking, swallowing and even breathing. Tumors arising from the cerebellopontine angle cause tinnitus, deafness, facial weakness, and corneal hypesthesias. These tumors usually grow slowly and changes due to increased intracranial pressure may not appear until late.

The major clinical characteristics of the five classes of meningiomas are briefly reviewed, and the roentgenographic changes are illustrated.—*Arno W. Sommer, M.D.*

Schnitker, Max T., and Ulrich, Robert P. Observations on the twenty-four hour pneumoencephalogram with special reference to the diagnosis of cortical atrophy. *Radiology*, Jan., 1958, *70*, 15–22. (Address: M. T. Schnitker, 1006 Secor Hotel Building, Toledo 4, Ohio.)

There has been general agreement among radiologists that air in the subdural space, apparent on the pneumoencephalogram, is of no diagnostic or pathologic significance. Demonstration of subdural air over the vertex of the brain in a twenty-four hour upright film, however, has been thought by some to indicate the presence of a subdural fluid collection in cases of the "post-traumatic syndrome" due to a tear in the subarachnoid membrane produced by a previous head injury. While others have felt that gas in the subdural space twenty-four hours after air injection was of no diagnostic significance it has also been stated that its presence is indicative of an error in technique.

Because of the ease of measuring this subdural space geometrically it was felt by the authors that such measurements might be an index for establishing the diagnosis of cortical atrophy. Consequently, a study was made on 66 patients who had nonprogressive lesions of the brain who were subjected to pneumoencephalography. Ninety per cent of the 51 adults showed the presence of air in the subdural space on the upright twenty-four-hour film and 66 per cent of the 15 children (under sixteen years of age) showed the same finding. From this series the authors feel that the presence of air and fluid in the subdural space does not indicate an abnormality. It is suggested that the air from the subarachnoid space reaches the subdural space through the pacchionian granulations that traverse both spaces and that the air is forced through the pacchionian bodies by the pressure of reaccumulating cerebrospinal fluid. The air-skull-capacity measurements and ratios also showed such wide variations, both individually and collectively, that cortical atrophy could not be diagnosed with any consistency. Unilateral cortical atrophy also cannot be diagnosed on the basis of a greater amount of subdural air over one cerebral hemisphere as this finding is thought to be due to the position of the patient in bed prior to the taking of the twenty-four hour roentgenogram.

From these studies the authors feel that the diagnosis of cortical atrophy remains presumptive only in the presence of dilated sulci and cisterns and enlarged subarachnoid spaces in the original penumoencephalograms.—*Donald N. Dysart, M. D.*

Etter, Lewis E., and Youngue, Eugene L. Small pneumoencephalograms as a screening procedure in the study of convulsive disorders. *Radiology*, Jan., 1958, *70*, 23–32.

(Address: L. E. Etter, 3811 O'Hara St., Pittsburgh 13, Pa.)

Pneumoencephalography using 20 to 30 cc. of air and multiple projections has been used to outline the ventricular system, particularly as a screening procedure in a large group of patients with convulsive and allied neuropsychiatric disorders. A definitive diagnosis can frequently be established, or further diagnostic studies may be indicated on the basis of the fractional pneumoencephalogram. Of particular advantage is the decreased reaction to the procedure, both immediate and delayed. In comparsion with a similar group of patients using 40 to 100 cc. of air it was found that the results were roughly comparable. However, a larger percentage of fourth ventricle visualization was obtained in the small pneumoencephalograms, probably due to the differences in technique in the two procedures, whereas there was a larger percentage of unsatisfactory examinations in the large pneumoencephalogram group for which there was no explanation.

The findings in several cases are detailed.—*Walter H. Jarvis, Jr., M.D.*

Lodwick, Gwilym S. Cystic degeneration in glioblastoma multiforme: Trapped-air sign. *Radiology*, Jan., 1958, *70*, 74–76. (Address: School of Medicine, University of Missouri, Columbia, Mo.)

The author describes and illustrates with two cases, a ventriculographic "trapped-air sign" of glioblastoma multiforme which is uniquely characterized by multiple, small, uneven, air-containing cysts within the tumor. This rapidly growing neoplasm frequently develops central liquefaction necrosis with the formation of multiple fluid-filled cysts, which communicate. If the tumor lies in the path of a ventriculography needle this fluid will be replaced by air. Other cystic lesions also may trap air. However, in contradistinction to the cysts of glioblastoma multiforme, they are usually large, smooth and unilocular. An outline of differential diagnosis is given.

When present, this "trapped-air sign" of glioblastoma multiforme has proved useful in localizing the tumor and in providing the diagnosis.—*Edward B. Best, M.D.*

Gloning, K., and Klausberger, E. M. Untersuchungen über die Hirngefässfunktion im Bewegungsfilm. (Investigations of the cerebral vascular function on the movie film.) *Wien. klin. Wchnschr.*, Feb. 28, 1958, *70*, 145–149. (From: Psychiatrisch-Neurologische Universitätsklinik, Wien, Austria.)

Experimental investigations on the function of the cerebral vessels in human beings are difficult. Routine serial angiography with 2 to 5 roentgenograms during the passage of the contrast medium provides few details.

Photofluorographic cinematography proved to be disappointing due to the low lens speed and the very grainy pictures, not well suitable for the demonstration of the cerebral vessels. In 1943 a patent for an image amplifying tube was granted to the Phillips Laboratories. The brightness of the output phosphor of this electronic image is a thousand times greater than that of the fluorescent screen image. By coupling an Arriflex 35 mm. camera with the intensifier tube, movie films with a frequency of 25 and more pictures a second were obtained. The single pictures, showing good contrast and fine detail, were suitable for enlargements. The authors found in this technique a method for investigation of the cerebral vascular system of patients with normal or pathologic blood vessels. The effect of vaso-active drugs could be demonstrated with this objective method.

The authors presumed they would not be able to get a true picture of the "normal" physiologic conditions of the cerebral vascular circulation since cerebral angiography represents a comparatively great interference with the normal vascular function. But with *unchanging* experimental conditions *comparable* data on the passage of the contrast medium through the single parts of the cerebral vessels could be gained.

The authors examined first the effect of the drug duvadilan of the N. V. Phillips-Roxane in Weesp-Netherlands.

Experiments on animals by other investigators had shown a blood pressure depressant and a vasodilative action, with little increase of the pulse frequency.

All cerebral angiographies were performed under general anesthesia for uniformity, starting with intravenous injection of 0.5 mg. atropine, then with narcothion 5 mg. per kg. intravenously, followed by N_2O-O_2 narcosis, and by 20 to 40 mg. lystenon as a fast acting muscle relaxant. Patients regained consciousness five to ten minutes after the injection. Details of the method of injection of the contrast medium are described. The movie film ran for twelve seconds, starting early enough to show entrance of the contrast medium into the carotid-syphon, and of sufficient duration to show the last amounts of the contrast medium leaving the calvarian vessels. Pictures were taken on Kodak 35 mm. Tri-X film. The authors show in two tables the results in fifteen patients, namely: beginning and ending of the contrast medium visualization in the arteria cerebri ant., arteria cerebri med., small arteries, veins and finally the venous sinuses.

From these investigations the authors arrive at the following conclusions: The movie film with the described method provides information on the function of the cerebral vessels. The functional reaction of the normal cerebral vascular system to contrast media and the reaction of the system to vaso-active

drugs could be demonstrated in detail on the movie film.

Previously Lindner had introduced the term of "Verweildauer" (lingering time) of the contrast medium in the end-vessels, which are the arterioles, precapillaries, arteriovenous anastomoses, venules and smallest veins.

With duvadilan the "Verweildauer" was shortened in 5 vascularly normal patients, in 3 patients with vascular sclerosis and in 3 patients after skull trauma. One patient with severe alcoholism also showed considerable reduction of the "Verweildauer." In 2 patients a vasodilative effect of duvadilan was observed.

The demonstration of cerebral angiography on the movie film with the new method furnishes measurable data of the reaction of certain cerebral vessels to vaso-active drugs. This brings in prospect new possibilities for studies of functional cerebral angiography and for increasing knowledge of cerebral vascular pathophysiology.—*Hans Lewin, M.D.*

Lagarde, C., Vigouroux, R., and Perrouty, P. Agénésie terminale de la carotide interne, anévrysme de la communicante antérieure; documents radiologiques. (Agenesis of the terminal end of the internal carotid, aneurysm of the anterior communicating artery; radiologic documents.) *J. de radiol., d'électrol. et de méd. nucléaire*, Sept.-Oct., 1957, *38*, 939–941. (From: Hôpital maritime Sainte-Anne, Toulon, France.)

Bilateral internal carotid arteriography revealed lack of filling of the terminal end of the right internal carotid as well as of the right anterior cerebral artery. On the left side an aneurysmal dilatation could be noted at the anterior communicating artery. The patient having shown clinical and laboratory signs of meningeal hemorrhage with severe headaches and hyperthermia, surgery was instituted and the arteriographic findings were verified. Agenesis of the terminal end of the internal carotid and aneurysmal dilatation at the junction of the anterior communicating artery and the anterior cerebral artery on the left side were found.

The proper surgical treatment of the aneurysmal dilatation could not be instituted because of the agenesis of the terminal end of the right internal carotid artery, and the patient died subsequently.—*Jirair N. Sarian, M.D.*

Paillas, J.-E., Bonnal, J., Berard-Badier, M., and Serratrice, G. Les angiomes artério-veineux du cerveau chez l'enfant. (The arteriovenous angiomas of the brain in childhood.) *Presse méd.*, March 26, *66*, 525–528. (From: Clinique Neuro-Chirurgicale de l'Hôpital de la Timone, Marseille, France.)

The authors present 11 cases of arteriovenous angiomas in patients ranging from four to fifteen years of age. The importance of bilateral internal carotid arteriography is pointed out in the diagnosis of such cases, especially in instances of intracranial hemorrhages, be they meningeal, cerebromeningeal or cerebral. The injection of the contrast medium should be made successively on each side, in particular if bilateral localization is suspected. The larger angiomas are easy to diagnose; the smaller ones are often not demonstrable, due to thrombosis or to compression by an adjacent hematoma. On the other hand the hematoma will displace the blood vessels which are visualized by arteriography only very faintly, but would tend to group them together, resembling the grouping of pleats of a curtain. This would only be noted in cases of very large hematomas.

Anatomopathologic considerations lead one to think of these arteriovenous angiomas as belonging to the group of hamartomas. The authors concur with Evans and Streeter and use the embryogenetic classification of Streeter. Thus three histologic types are described, the capillary endothelial, the undifferentiated arteriovenous and the adult type which could be purely arterial or purely venous.—*Jirair N. Sarian, M.D.*

Neck and Chest

Dybicki, Jerzy, Bochinski, Karol, and Dworak, Wlodzimierz. Über einen Fall von zusätzlichem Trachealbronchus. (Case of accessory tracheal bronchus.) *Schweiz. Ztschr. Tuberk.*, No. 2, 1958, *15*, 70–75. (Address: J. Dybicki, Fahrenheita 4, Gdansk, Poland.)

This is a case report of a twenty year old man with extensive tuberculosis of the lungs, in whom an accessory bronchus in the right upper lobe was found accidentally during bronchoscopy. The bronchial opening was seen 2 cm. above the carina. Laminagraphy and bronchography confirmed the diagnosis.

This condition is seen very seldom. Frequently, the extra bronchus is the seat of a pathologic process, such as bronchiectasis or cystic-like disease.—*Samuel Richman, M.D.*

Scheff, Saul, Kaufman, S. A., and Levene, George. The laminagraphic appearance of ectopic right upper lobe bronchi. *Radiology*, Jan., 1958, *70*, 82–83. (Address: Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.)

The appearance of an anomalous bronchus arising from the distal portion of the right side of the trachea approximately 1.0–2.5 cm. above the carina is described by the authors who use laminagraphy in their study of patients with intrathoracic disease. Plain

roentgenograms of the chest usually fail to reveal these ectopic or supernumerary bronchi, but they are demonstrable through the use of laminagraphy.

The authors stress the importance of recognizing these variations prior to bronchoscopy or surgery so as to forewarn the surgeon of the existence of the bronchus. Three roentgenograms illustrating the anomaly are included.—*John S. Alexander, M.D.*

Barthel, Heinz. Diagnostische Fehldeutung chirurgischer Lungenerkrankungen. (Diagnostic errors of surgical diseases of the lungs.) *Thoraxchirurgie*, March, 1958, *5*, 412–430. (Address: Chirurgische Universitätsklinik, Hamburg-Eppendorf, Germany.)

Of 800 operative cases with intra and extrapulmonary disease in the region of the thorax, there was a diagnostic error of 10 per cent prior to operation. Sixty per cent of the errors were made when the patient was believed to have a carcinoma of the lung before operation. One-third of these patients had "chronic pneumonia."

It is the policy of the author not to wait longer than four weeks in doubtful cases of carcinoma of the lung, so that if a carcinoma is present, operation will have been done as early as possible. Tuberculosis of the lungs plays a significant role in the differential diagnosis and the isolation of the tubercle bacillus is very important. Foreign body obstruction of a bronchus, actinomycosis, syphiloma, thymoma, sarcoma of lung, bronchiectasis, etc., were other conditions observed.

The correct diagnosis of tumors in the anterior mediastinum is particularly difficult.—*Samuel Richman, M.D.*

LaVielle, Carroll J., and Campbell, Darrell A. Neurofibromatosis and intrathoracic meningocele. *Radiology*, Jan., 1958, *70*, 62–66. (Address: C. J. LaVielle, 326 N. Ingalls St., Ann Arbor, Mich.)

Intrathoracic meningocele is a rather uncommon entity and usually occurs in conjunction with other abnormalities. This condition was first reported by Pohl in 1933, in whose case the associated finding was cutaneous neurofibromatosis. Since that time 29 cases have been reported, 19 of which were associated with neurofibromatosis. Of 3 bilateral cases, 2 were associated with neurofibromatosis.

A case of bilateral intrathoracic meningocele with cutaneous neurofibromatosis is presented. Roentgenograms showed a rounded mass in the right posterior chest with defects in the posterior margins of the lower thoracic vertebrae and dislocation of the right eleventh rib. A diagnosis of intrathoracic neurofibroma was made. This was found to be a meningocele at the time of surgery. On routine postoperative follow-up films, another mass was discovered in the left retrocardiac space and this too turned out to be a meningocele.

Etiology is discussed with reference to various authors. The most frequent findings are defects in the vertebral column adjacent to the intrathoracic mass, this finding being present in all but 4 of the 30 cases reported in the literature. The authors conclude that meningocele formation is due to congenital anomalies of mesodermal structures of the spine, such as dural defects, softened bone, hemivertebra formation or defective pedicles. A combination of dural and bone defects is probably necessary since bone defects alone can occur without meningocele formation. Variations in spinal fluid and intrathoracic pressures may be contributory factors in the herniation.—*Z. Petrany, M.D.*

Barcia, A., Oliveira Ilha D., Fiandra, O., and Cortés, R. Nuevas adquisiciones en el diagnóstico radiológico de las cardiopatías. (New acquisitions in the roentgenologic diagnosis of cardiopathies.) *Acta iber. radiol. cancerol.*, April-June, 1957, *12*, 197–231.

This is a well illustrated summary of the authors' experience with high kv. techniques and serial angiocardiography.

The judicious employment of these methods, and their association, in adequately selected patients, with other procedures, such as cardiac catheterization, improves the chances for accurate diagnosis.—*E. R. N. Grigg, M.D.*

Stevens, G. Melvin. Buckling of the aortic arch (pseudocoarctation, kinking): a roentgenographic entity. *Radiology*, Jan., 1958, *70*, 67–73. (Address: Palo Alto Medical Clinic, Palo Alto, Calif.)

Four cases of buckling of the aortic arch are presented by the author. At the present time, fewer than 35 cases have been recorded in the English literature and the roentgenographic appearance, which is diagnostic, is not generally appreciated. The anomaly, which is believed to be due to a congenitally shortened ligamentum arteriosum, is a buckling or a kinking of the contour of the aortic arch at the site of insertion of the ligamentum arteriosum. There is a posteriorly directed double convexity of the aortic arch and upper descending aorta. The portion of the arch above the kink usually ascends higher into the superior mediastinum than normally, then descends to the right. The buckling does not diminish the aortic lumen. Senescence, with tortuosity and dilatation, accentuates the deformity. There are no significant clinical symptoms associated with this anomaly except for a precordial systolic murmur probably produced by increased turbulence at the site of the kink. The blood pressure and pulse are normal in all the extremities.

Roentgenographically, the posteroanterior film may reveal a large aortic knob with an abrupt indentation at its inferior pole and a second convexity in the descending aorta below this point. In other cases, a double convex contour of the knob is seen with the superior convexity less dense than the inferior. The arch distal to the kink produces an indentation on the barium filled esophagus and the lateral or left anterior oblique view with lateral laminagrams will confirm the diagnosis. In these views, the sharp indentation on the posterior and left lateral surface of the aorta at the level of attachment of the ligamentum arteriosum can be seen. The aorta distal to the kink may be slightly dilated due to turbulence. This benign condition must be differentiated from such surgical entities as coarctation of the aorta, aneurysm of the aortic arch, and patent ductus arteriosus by correlating clinical and roentgenologic findings.—*John S. Alexander, M.D.*

Genitourinary System

Taylor, Jack N., and Genters, Klaus. Renal angiomyolipoma and tuberous sclerosis. *J. Urol.*, April, 1958, *79*, 685–696. (From: The Department of Surgery [Urology], College of Medicine, Ohio State University, Columbus, Ohio.)

This is a report of three case histories in which the patients had the common finding of a renal angiomyolipoma. In two of the patients there were also the other characteristic stigmata of tuberous sclerosis.

Tuberous sclerosis is a more or less generalized disease of varying severity and having a familial tendency. The clinical findings include mental retardation, epilepsy and sebaceous adenomas of the face. Generalized hamartomas occur in many organs such as the brain, pancreas, duodenum, thyroid, breast, skin and subcutaneous tissues. The lesions in the brain are histologically described as composed of neuroglial proliferations, and those in other organs are derived from ectoderm or mesoderm. In well over 50 per cent of the reported cases there are tumors of the kidney. These are usually hamartomas, but sarcomatous changes have also been observed. The larger kidney tumors may simulate polycystic disease as seen on the pyelograms. Benign tumors of the retina and optic nerve called phacoma are pathognomonic of the disease. Other roentgen changes are calcifications of the brain and areas of increased density in the skull, vertebrae and ilium. The hands and feet may show cyst-like foci in the phalanges and periosteal new bone formation along the shafts of the metatarsal and metacarpal bones.

In two patients reported in this series there was evidence of familial tendency, sebaceous adenomas of the face, subungual and periungual fibromas, bone changes involving the hands and feet and bilateral tumors of the kidney.

Fourteen figures are used to illustrate the findings.—*George W. Chamberlin, M.D.*

Auvert, Jean. Læs reflux à partir du bassinet; étudies par la manométrie urinaire. Pathogénie des néphrites interstitielles ascendantes. (Reflux from the kidney pelvis, studied by urinary manometry. Pathogenesis of ascending interstitial nephritis.) *J. d'urol., Paris*, Dec., 1957, *63*, 824–887. (From: Service du professeur R. Couvelaire, Hôpital Necker, Paris, France.)

The degree of renal parenchymal damage depends on whether urinary obstruction is total or partial, and transient or persistent, but even ureteral adynamy and vesico-uretero-pyelic reflux may become harmful. Dilatation of the urinary excretory channels with intrarenal reabsorption of urine can seldom be helpful. Such an event may be tolerable for a short time during acute obstruction (such as due to ureteral calculus), but even in these cases parapyelic and interstitial urinary diffusion may at times be seen on the urograms. When, however, there is permanent obstruction (hydronephrosis with compressive parenchymal atrophy), or when intrarenal penetration of microorganisms (incomplete obstruction in the presence of infected urine) produces retrograde interstitial nephritis, lasting functional impairment is bound to occur.

Intrarenal reabsorption parallels the mechanism of pyelorenal reflux observed during retrograde pyelography, *i.e.*, pyelo-canalicular, pyelo-interstitial, pyelo-lymphatic, and finally pyelo-venous and subcapsular "effraction". The canalicular, interstitial, and lymphatic types of reflux can be observed at less than 80 cm. water pressure, but higher or longer lasting increases in pressure are necessary to produce "effraction". But then, chronic stasis does modify parenchymal permeability with respect to reabsorbed urine, at which stage the first three types of reflux start to occur at even lower pressures, which soon leads to grave impairment of renal function.

Measurements of the urinary pressure have shown 10–15 cm. water equivalents in the kidney pelvis, increasing steadily downstream with the help of pyelo-ureteral peristalsis, so as to reach 40–50 cm. in the juxtavesical ureter, needed to effectuate intravesical ejaculation. Ureteral adynamy, such as that due to congenital mega-ureter, causes stasis and secondary infection, which sooner or later diffuses throughout the renal parenchyma. Conversely, excretory obstruction is associated with urinary hyperpressure, as a result of the differential pressure of ultrafiltration; under these circumstances, urinary pressure reaches a maximum, which is constant, and represents in a healthy kidney about 40 per cent of the median arterial pressure.

Under physiologic circumstances, this maximum

urinary pressure reaches 80–90 cm. The hydronephrotic kidney, with shrunken arterioles, cannot elevate this pressure beyond 40 cm. The reduced filtration in the sclero-atrophic kidney barely reaches 25 cm. The pyonephrotic kidney no longer filters urine, and the feeble 10–15 cm. pressure equals the prevalent intra-abdominal pressure. The author recommends routine urinary manometry (during cystoscopy with retrograde ureteral intubation), both as a means of more accurate evaluation of the individual case, and to prevent excessive pressure during instillation of contrast medium. Moreover, associated with roentgen cinematography, study of the metabolism of electrolytes and renal biopsy, measurement of the urinary pressures in the ureter and kidney pelvis should be of value on a research basis.—*E. R. N. Grigg, M.D.*

Hanafee, William, Ottoman, Richard E., and Wilk, Stefan P. Roentgen diagnosis of urinary complications following radical hysterectomy and pelvic lymph node dissection. *Radiology*, Jan., 1958, *70*, 56–54. (Address: W. Hanafee, University of California Medical Center, Los Angeles 24, Calif.)

The roentgen aspects of complications occurring in the urinary tract following radical hysterectomy using Wertheim's technique are described and illustrated by clinical examples. These major complications are a result of deficient blood supply with resultant tissue necrosis, and as there is some loss of bladder sensation due to altered nerve supply they may not be suspected or recognized for several days until a communication is actually established with the exterior either through the vagina, skin, or rectum. With a thorough knowledge of the anatomy and surgical techniques employed, the roentgen findings can be predicted and the time sequence of their possible appearance established. It is obvious that the more extensive the removal of potential cancer-bearing tissue, the greater the likelihood of injury to normal organs in the operative area.

An analysis of follow-up roentgenograms in the postsurgical period in 25 cases of radical hysterectomy with pelvic lymphadenectomy constituted the basis for this study. The postsurgical urinary tract complications found were divided into 2 distinct groups: early and late. The early or immediate complications consisted of a generalized ectasis of the upper collecting system, including the ureters, diminished excretory function of the kidneys, bladder atony, and urinary infection secondary to stasis. Surgical trauma, edema, and ischemia are primarily responsible for these findings, with the severance of the ureteral and pelvic visceral nerve supply being a contributing factor. Excretory urography in the immediate postoperative period will usually show the ectasia of the pelvicalyceal system and the ureters. This ectasia will gradually regress as the ureteral edema disappears. A cystogram will show the bladder atony and postvoiding films will show the large amounts of residual urine.

The late or delayed urinary tract complications include fistulas of all types, ureteral strictures, persistent dysfunction of the urinary bladder, and chronic infection of the urinary tract. The first two are important for the radiologist to recognize as the therapeutic approach will ultimately depend upon the roentgen manifestations of their course. In the latter two the roentgenologic findings are not essential for their diagnosis. Ureterovaginal fistulas are the most frequent, vesicovaginal next. These make their appearance on the average seven to fourteen days after surgery. Excretory urograms will show extravasation of the contrast medium as an ill-defined shadow at the level of the intrapelvic portion of the ureter, spreading within the retroperitoneal space between fascial planes. Retrograde pyelograms may demonstrate the exact site of the fistulous tract. Sometimes combinations of cystoscopy and contrast studies and intravenous pyelography are necessary to differentiate between ureterovaginal and vesicovaginal fistulas. Ureteral stricture, the second most serious delayed complication, can be demonstrated by excretory urography. During the first few weeks a narrowing of the terminal segment of the ureter with hydronephrosis due to edema of the mucosa and wall will be seen. This usually subsides in about one month but if the damage is sufficient fibrous tissue will replace the normal musculature and in three or four months a stricture will be present resulting in hydronephrosis or even a completely nonfunctioning kidney. Rectovaginal fistulas have not as yet been encountered.—*Donald N. Dysart, M.D.*

Guze, Lucien B., and O'Shea, William. Experimental hydronephrosis produced by beta irradiation of the ureter. *J. Urol.*, May, 1958, *79*, 801–806. (From: The Departments of Internal Medicine and Radiology, Yale University School of Medicine, New Haven, Conn.)

The authors discuss the findings in groups of rats following the application of variable doses of beta radiation to the ureters.

A control group of animals was subjected to the same operative procedure without the use of a radioactive applicator. All of these animals exhibited transient hydronephrosis. The changes occurred one day after the ureteral compression, persisted for seven days and then gradually subsided. In this group, the animals examined at the end of thirty days had normal pyelograms.

In 8 animals 300 rep was administered directly to the left ureter. All these animals developed hydronephrotic changes of a degree and duration similar to those seen in the control group and the pyelograms were normal at the end of thirty days.

Twenty rats received 700 rep directly to the left ureter. In this group the maximum hydronephrotic changes were seen one week following irradiation and persisted to the fourth week. Thereafter a decline occurred until the seventh or eighth week when a secondary rise began which reached its peak twelve weeks after exposure to beta irradiation.

In 10 animals 1,500 rep were applied to the left ureter. In these animals a sustained uniform degree of hydronephrosis persisted until the twelfth week, after which a beginning decrease was noted.

Examination of the rat kidneys at varying intervals after irradiation demonstrated changes compatible with those found by intravenous pyelography.

Macroscopically the renal pelves and proximal ureters were overdistended. The kidneys were enlarged and dark in color and microscopically there was a tubular dilatation of varying degrees.

Beta irradiation was used in these experiments to produce ureteral trauma with resultant scarring and partial obstruction. The applicator consisted of a smooth surfaced strontium 90 applicator about 0.5 cm. in diameter. It was applied directly to the left lower ureter at laparotomy.

The effects of the beta radiation observed were similar to those described by other authors and included a primary reaction noted within six hours and persisting for two to four days, followed by secondary erythema and pigmentation. In those animals exposed to higher doses, the primary and secondary reactions persisted for a longer time. In the animals irradiated with 1,500 rep, the persistent duration of the hydronephrosis represented a more prolonged response to higher doses of irradiation. Continued studies might have revealed a delayed secondary response in this group.—*George W. Chamberlin, M.D.*

Fisher, Mary S., Torre, Anthony V., and Wohl, G. T. Fatal uremia due to uric acid crystals in a case of lymphosarcoma. *Radiology*, Jan., 1958, *70*, 84–86. (Address: M. S. Fisher, University and Woodland Aves., Philadelphia 4, Pa.)

Uremia is a rare and partially avoidable complication of radiation therapy of the lymphoma group of neoplasms which occurs as the result of uric acid precipitation in the urinary tract. The authors report such a complication in a case of abdominal lymphosarcoma in a twenty-four year old male. A positive diagnosis was established at laparotomy after which the patient was given daily roentgen therapy through a single 18×20 cm. anterior mediastinal and upper abdominal field. Seven treatments in seven days, in increments of 200 r in air per day (after the initial two treatments of 150 r each) resulted in an air dose of 1,250 r and a tumor dose of 660 r (250 kv., half-value layer 1.35 mm. Cu, distance 50 cm.). The patient developed oliguria on the second day of therapy and subsequently expired on the seventh day of treatment. An autopsy revealed both ureters to be occluded by uric acid crystals.

Since uric acid is the end product of purine metabolism, any process which increases nucleoprotein breakdown will produce increased levels of uric acid in the blood and urine. This may occur spontaneously but should be expected with any therapy which increases cell breakdown. The authors propose certain steps to minimize or prevent this occurrence which includes recognition of the possibility and careful evaluation of the kidney status. Prophylactic measures include a high fluid intake, low purine diet, alkalinization of the urine and perhaps the use of cinchophen. If obstruction occurs the ureters should be catheterized and antibiotic therapy instituted.—*Edward B. Best, M.D.*

Kincaid, Owings W. Translumbar aortography. *South M. J.*, April, 1958, *51*, 455–464. (From: The Section of Roentgenology, Mayo Clinic, Rochester, Minn.)

The author discusses the indications, contraindications and his technique for translumbar aortography. His experience is based on the performance of more than 1,000 aortographies by the translumbar route at the Mayo Clinic. A good detailed description of the technique is given. The method is not innocuous and there were 4 serious and 5 minor complications in the 1,000 cases with no deaths.

The 4 serious complications were: (1) Anuria and ileus (after injection of both the superior mesenteric and renal artery); (2) pneumothorax; (3) chylothorax (injection made into inferior vena cava); and (4) esophagitis (after periaortic injection).

The 5 minor complications consisted of mild reactions to the contrast medium manifested by urticaria.

In 42 cases a displaced injection occurred which was as follows: Periaortic (23 cases); intramural-aortic (5); superior mesenteric artery (5); left renal artery (4); celiac axis (2); splenic artery (1); lumbar artery (1); and inferior vena cava (1).

The author concludes that aortography should be performed only when it can be expected to provide the surgeon with important information that cannot be obtained by simpler and safer means.—*C. Peter Truog, M.D.*

Van Velzer, David A., and Lanier, Raymond R. A simplified technic for nephrotomography. *Radiology*, Jan., 1958, *70*, 77–81. (Address: D. A. Van Velzer, 4200 East Ninth Ave., Denver 20, Colo.)

A technique of laminagraphy to outline the kidneys is described and is referred to by the authors as nephrotomography, a term first used by Evans *et al.*

in 1954. The method is as follows: The circulation time is determined by injecting 5–10 μc of I^{131} into an antecubital vein, with a scintillation counter centered over the upper lumbar area. Fifty cubic centimeters of 70 per cent urokon is then injected in two seconds through a large caliber needle into an antecubital vein. Three anteroposterior roentgenograms of the abdomen are taken and timed so as to show three phases of the injection. The first is made to visualize the aorta and renal arteries; the second to show the nephrographic phase which occurs about ten to twelve seconds after beginning the injection; and a third exposure as a tomogram through the kidney at a depth determined by a preliminary film. The whole procedure from the time of injection takes about twenty-five seconds.

Indications for nephrotomography are: (a) to differentiate between renal cysts and neoplasms, (b) to study renal blood supply, (c) to determine renal function, (d) to substantiate inconclusive intravenous and retrograde pyelographic studies. Contraindications are the same as for intravenous pyelography.

The results of 34 nephrotomographic studies performed by the authors are discussed, and three case histories are presented to illustrate the value of this technique.—*Z. Petrany, M.D.*

Skeletal System

Hinkel, C. L. Fractures of the distal radius and ulna and dislocation of the proximal carpals. *Radiology*, Dec., 1957, *69*, 809–814. (From: George F. Geisinger Memorial Hospital, Danville, Pa.)

Trauma to the wrist frequently results in fractures and dislocations of the involved bones which can be diagnosed roentgenographically only with difficulty after special examinations. Occasionally re-examination after an interval of several days will reveal the presence of a healing fracture which was not evident at the time of the original examination. The occurrence of accessory carpal ossicles, double ossification centers, and old un-united fractures makes the diagnosis of recent fractures all the more difficult and sometimes impossible.

Any of the carpal bones may become dislocated with or without fracture. Dislocation of the lunate bone is frequently overlooked. The relationship of the capitate, the lunate, and the radius, which is best evaluated in the lateral view, should be checked in every case of wrist trauma to rule out isolated dislocation of the lunate, or retrolunar dislocation of the carpus. Epiphyseal separations are essentially fractures through the distal metaphysis. Following reduction, union is usually satisfactory, and there is seldom any deformity or impairment of growth. Crushing injuries of the epiphyseal cartilage are more serious, often resulting in premature fusion. The radius is most often affected.—*Walter H. Jarvis, Jr., M.D.*

Brown, Webster H., Dennis, John M., Davidson, Charles N., Rubin, Paul S., and Fulton, Harold. Posterior dislocation of the shoulder. *Radiology*, Dec., 1957, *69*, 815–822. (Address: W. H. Brown, 11 East Biddle St., Baltimore 2, Md.)

Posterior dislocation of the shoulder is an infrequent injury. It is therefore often overlooked, especially when associated with other severe bodily injuries or with a fracture of the upper humerus. Serious disability may result if the dislocation is not detected and reduced promptly. The following roentgenographic projections are all useful and may succeed in certain circumstances (no one projection is uniformly successful): anteroposterior; anteroposterior stereoscopic, horizontal shift; anteroposterior stereoscopic, vertical shift; anteroposterior in internal and external rotation; transthoracic lateral; superoinferior or inferosuperior with arm abducted; axial and semioblique views of the scapula; and laminagraphic exposures.

Typical cases and end-results are presented.—*Arno W. Sommer, M.D.*

Nagle, Douglas B., Whiplash injuries of the cervical spine. *Radiology*, Dec., 1957, *69*, 823–827. (Address: 117 West 8th Street, Erie, Pa.)

The whiplash injury consists in a hyperflexion of the neck resulting from a violent forward thrust of the head when the motion of the body has been suddenly slowed or stopped. This injury also occurs as a recoil hyperflexion following hyperextension produced by acceleration of the body from behind. The author has reviewed the less obvious roentgenographic evidence of the cervical spine injuries resulting from this so-called whiplash mechanism. Obvious injuries such as fractures and dislocations are not considered. The complete examination may require, in addition to the standard roentgenograms, stereoscopic roentgenograms and laminagrams. Roentgenograms in lateral views made in flexion and extension and in oblique views may also be necessary.

The types of fractures most commonly found in whiplash injuries are those involving the lateral masses, posterior arches, transverse or spinous processes of the vertebra, or chip fractures of the anterior margins of the body. Odontoid process fractures may also occur. The less obvious injuries include those to the ligaments such as a tear, avulsion, or capsular rupture, and muscular injuries such as strains. The ligamentous and muscular injuries are best demonstrated by the flexion or extension roentgenograms which will show a loss or reversal of the normal cervical curvature and an uneven separation of the spinous processes upon flexing the neck.

These ligamentous and muscular injuries, though seemingly not as important as fractures, form a positive basis for definite treatment.—*Donald N. Dysart, M.D.*

Bavendam, Frederick A. Fractures of the carpal bones. *Radiology*, Dec., 1957, *69*, 828–830. (Address: Mercy Hospital, Springfield, Ohio.)

The author reviews the problem of roentgen diagnosis of fractures of the carpal bones. Emphasis is placed on meticulous roentgen technique after thorough clinical examination in order to minimize errors in diagnosis and consequently reduce residual incapacity in patients suffering carpal injury. The minimum examination of the wrist should include roentgenograms in the posteroanterior view made with the hand in partial ulnar deviation, in an oblique view with the hand in partial pronation, and in a true lateral view. Other special views may be required. A cardboard holder with nonscreen film is used as this affords better detail.

Navicular fractures are the most common carpal fractures and the most important because of their propensity to nonunion and avascular necrosis resulting in permanent disability. Displaced fractures of the proximal third of the navicular bone are especially prone to nonunion and avascularity. Dislocations are more common than fractures in the case of the lunate. Fractures of the triquitral bone are best seen in the lateral view and commonly produce no late sequelae. Fractures of the greater multangular bone are rare, usually being chip fractures associated with a navicular fracture. The lesser multangular bone is rarely fractured and when a fracture is found, this is of compound type as a rule. The capitate is relatively well protected and only chip fractures or fractures of the proximal third of the bone in association with navicular fractures have been reported. Occasional fractures of the hamate are recognized, usually in conjunction with fracture or dislocation of the fourth or fifth metacarpals.—*John Alexander, M.D.*

Piatt, Arnold D. Some significant aspects of fractures of the calcaneus. *Radiology*, Dec., 1957, *69*, 831–836. (Address: 36 West Locust St., Newark, Ohio.)

Routine lateral and axial or tangential roentgenograms of the calcaneus frequently are insufficient to rule out less evident fractures. In such instances, examination should be supplemented with roentgenograms made in Anthonsen's oblique projection and in an inversion-oblique view. A Bucky axial view of the injured heel and a lateral comparison with the uninjured heel will often be of considerable value.

Calcaneal fractures are classified into 2 major categories—those that involve the subtalar joint and those that do not. There are many subdivisions in each of the major groups, so arranged as to obtain a prognosis and determine the type of treatment. All treatment is aimed to restore as much as possible the normal anatomic arrangement in order to permit the normal physiologic mechanics to function. The fact that almost 40 per cent of calcaneal fractures require surgical intervention, and that long periods of convalescence may be necessary, indicates that radiologists must do their utmost to properly evaluate injuries to this bone.

The different types of fractures and their mechanism of production are discussed.—*Donald N. Dysart, M.D.*

Jones, Paul A. The immediate prognosis of intracapsular fractures of the neck of the femur. *Radiology*, Dec., 1957, *69*, 837–838. (Address: 737 Market St., Zanesville, Ohio.)

The role of the radiologist in the diagnosis and management of fractures is discussed. Planning the type of reduction and its actual performance should be under the direct authority of the radiologist who in turn should be competent in orthopedic roentgenology.

In determining the prognosis of intracapsular fractures of the femoral neck, 4 points are important: (1) A fracture line of less than 30° to the horizontal has a good prognosis even without internal fixation. A 30°–50° fracture line requires perfect internal fixation, whereas those between 50°–90° to the horizontal bear an unfavorable prognosis even with accurate nailing. (2) Abduction type fractures have a much better prognosis than adduction types; the latter types should be transformed to an abduction type. (3) Extremely demineralized bone forms poor callus and even with excellent reduction the prognosis is unfavorable. (4) Severe comminution of the medial margin of the neck and shaft fragments, such as those seen in automobile accidents with extreme trauma, definitely have poor union. Anteroposterior roentgenograms should always be taken with the limb in complete internal rotation. Frogging of the leg should never be attempted when making roentgenograms in lateral views.—*Z. Petrany, M.D.*

L. D. MARINELLI

Janeway Lecturer, 1958